U. S. DEPARTMENT OF AGRICULTURE.
OFFICE OF EXPERIMENT STATIONS—BULLETIN NO. 130.
A. C. TRUE, Director.

EGYPTIAN IRRIGATION:

A STUDY OF IRRIGATION METHODS AND ADMINISTRATION IN EGYPT.

BY

Thomas
CLARENCE T. JOHNSTON,
ASSISTANT CHIEF, IRRIGATION INVESTIGATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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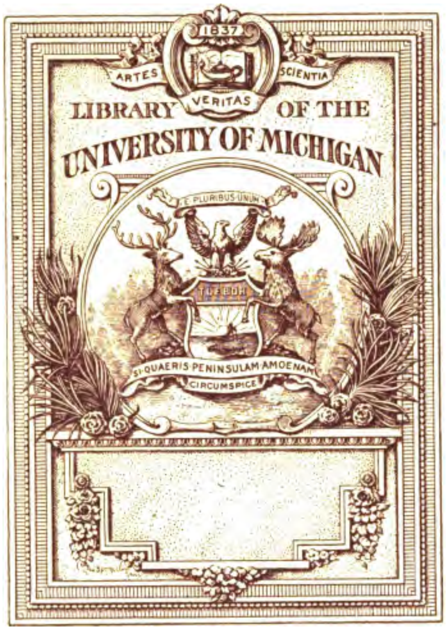
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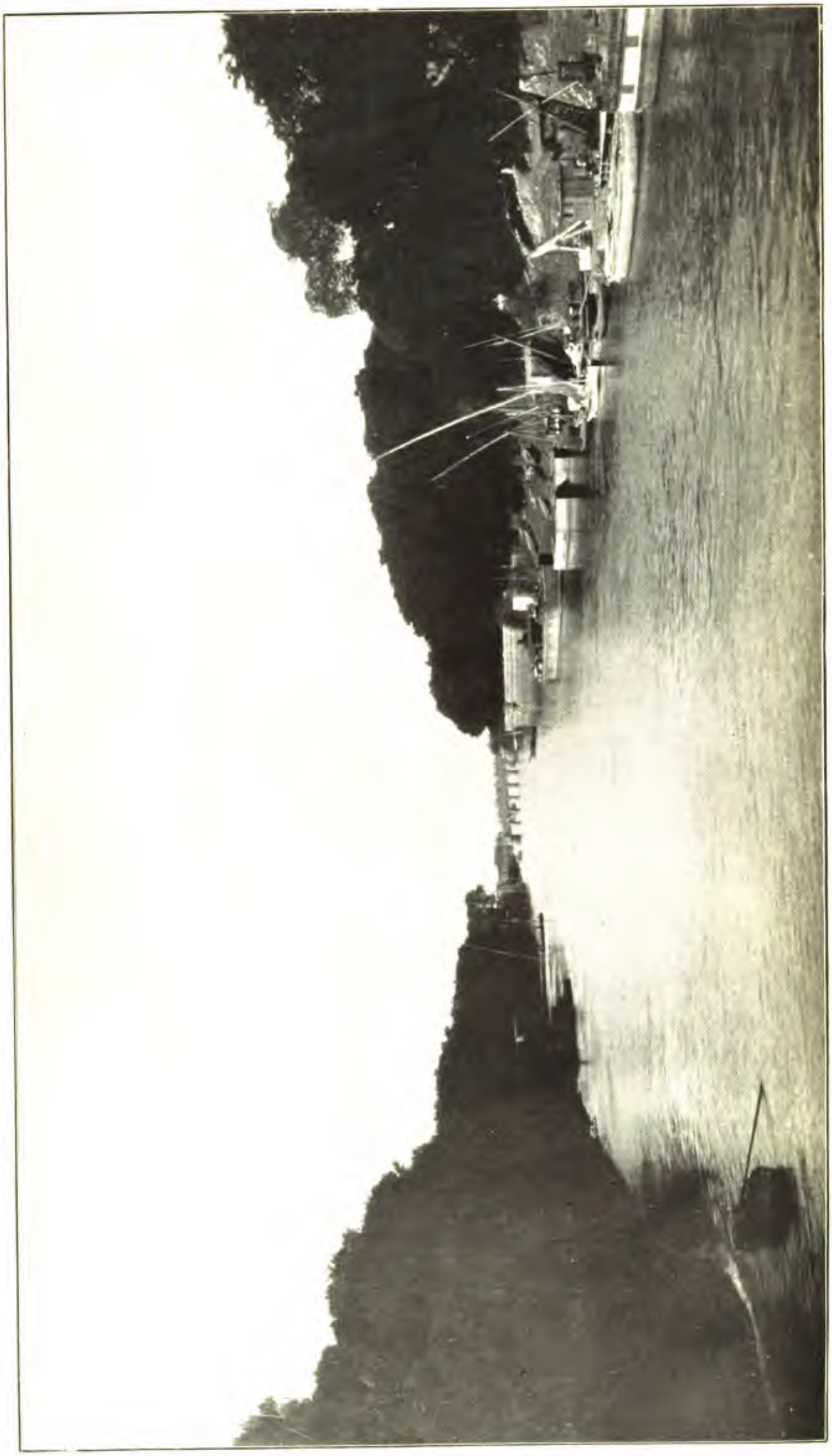

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OFFICE OF EXPERIMENT STATIONS.

A. C. TRUE, Ph. D., *Director.*
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IRRIGATION INVESTIGATIONS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., May 20, 1903.

Sir: I have the honor to transmit herewith and to recommend for publication a report on Egyptian irrigation, prepared under the direction of Elwood Mead, chief of irrigation investigations of this Office, by C. T. Johnston, assistant chief.

This report gives the results of observations made by Mr. Johnston during the winter of 1901–2 on the irrigation works, practices, and administrative system of Egypt, under authority of the act of Congress making appropriations for the irrigation investigations of this Office, which provides, among other things, for investigation and report upon "the laws * * * and institutions relating to irrigation and upon the use of irrigation water at home or abroad."

The bulletin is illustrated by twenty-five full page plate illustrations and nine text figures, all of which are necessary to a complete elucidation of the text.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., May 20, 1903.

SIR: I have the honor to submit herewith a report on Egyptian irrigation, prepared by Clarence T. Johnston, assistant chief of irrigation investigations of this Office. Mr. Johnston spent the winter of 1901–2 in Egypt, making a study of irrigation methods and laws. This report gives the results of his observations and inquiries.

In the valley of the Nile irrigation has been practiced for thousands of years, and if time and experience were in themselves sufficient we ought to find water distributed with more skill and used with better results there than in any other country. Such, however, is not the case. On the contrary, the irrigators of this country have little to learn from Egypt so far as practical methods are concerned. The reasons for this are not obscure. One is the lack of inventive and mechanical skill on the part of the fellah. Here every implement used in agriculture has been subject to constant change and improvement; the Egyptian still uses a crooked stick for a plow and beats out his corn as did his ancestors in the time of the Pharaohs. In this country we have already evolved special machinery for the construction of canals, building of laterals, and cleaning out and enlarging of ditches; in Egypt many canals are still cleaned by throwing the mud out by hand. The lessons of Egypt, therefore, so far as irrigation practice is concerned, are of negative value. There is another reason why this is so. Irrigators in Egypt are paid 15 cents a day. Their methods are possible only with this low wage rate, hence they can not be adopted in a country like ours, where higher wages are paid.

The showing of the yield and profits of irrigated land in Egypt is, however, full of significance and promise to the arid commonwealths. It is only on irrigated land that the average net return from sugar cane reaches \$80 to \$85 an acre. The revenues of the Egyptian Government from the areas devoted to dates runs from \$10 to \$45 an acre, and the net profit to the cultivator approximates \$150 an acre. This little tract of agricultural land, no larger than the irrigable area of

California, supports between 5,000,000 and 6,000,000 people, pays the expenses of a costly government, and meets the interest on a national debt half as large as our own from the returns on agriculture alone.

Three subjects have a vital relation to the future extension of irrigation in this country. These are storage, drainage, and the utilization of water by pumping. The great storage works of Egypt have especial interest to our Government engineers; but Egypt has few examples of the small storage works such as are being built in large numbers by private parties in the West and which are destined to be an important feature of our irrigation systems. The accumulation of alkali in the surface soil, which has already become a troublesome feature in Western irrigation, at one time rendered unproductive large areas in lower Egypt. These are being reclaimed by drains which carry off the excess of salts and tend to prevent their further accumulation. So far as lifting water from wells or streams is concerned, the devices in Egypt are inferior to the gasoline and electric engines and centrifugal pumps now extensively used in the West. Some of the simpler and cheaper devices of Egypt are efficient for the lifting of small quantities of water, and there are many places in this country where such machines can be used to advantage.

Mr. Johnston's description of the dams built by the French and English Governments will have much interest. Their success from an engineering standpoint and the great benefits which have come to the people from this expenditure of government funds are unquestioned. But it is doubtful if we can adopt the administrative methods employed in Egypt. Political and economic conditions in that country differ so widely from our own that methods which are there useful are clearly inapplicable here. Egypt is governed by a foreign power, which has assumed arbitrary control over the water supply, recognizing no rights as belonging to the users of this water. Such a system has brought about an efficient use of the Nile, but it is repugnant to American ideas. It is a success in Egypt because of lack of means on the part of the agricultural population and lack of the experience in business and political affairs, needed for the successful operation of irrigation systems under private ownership. The American farmer has both the economic ability necessary to the management of irrigation works and the political power and the intelligence to create institutions for controlling the water supply which will be in harmony with our ideas of free government. The study of Egyptian laws and administrative methods, while interesting, is of little value as an example to be followed.

Respectfully submitted.

Elwood Mead,
Chief of Irrigation Investigations.

A. C. True, *Director.*

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EGYPTIAN IRRIGATION.

INTRODUCTION.

The studies on which this report is based were made during the winter of 1901–2 as a part of the work of the irrigation investigations of the U. S. Department of Agriculture. The object was not the compiling of an exhaustive treatise on Egyptian irrigation, but rather the study of agricultural practices, engineering works, and administrative measures for comparison with American works and methods, with a view to the improvement of the latter, giving especial attention to administrative methods.

The plan followed was to become conversant with the irrigation law of Egypt, then follow its application in the field. Such a study of irrigation administration can best be carried on with Cairo as a base. All the engineers having charge of the division of water have their offices there, and it is easy to reach any other part of the country from that city. Fortunately the laws had been compiled in French during the year 1901, and copies could be had for the asking.

The inspector of irrigation was absent from Cairo during the winter of 1901–2, and his duties were attended to by the inspectors of Lower and Upper Egypt. Under any circumstances these two officers and the chief of the technical department, who has charge of the installation of water-raising devices and the inspection of steam boilers used in connection with pumps, shoulder a large part of the responsibility. These officers gladly gave such information as they had in their possession, and referred such inquiries as they could not answer directly to those who were informed on the subject.

The great Nile dams would naturally be examined by one interested in irrigation, and the canals can be studied with profit. One feature of Egyptian irrigation which is almost lacking in America is the use of water-raising devices. The Egyptian farmer seldom is able to secure enough fall to permit the delivery of water by gravity alone. The problem of raising water from some of the streams of the United States will have to be solved in the near future. Wherever a river flows in a canyon or where the grade of a stream is small it is often advantageous to lift the water to the head of a canal instead of building a long or difficult line. It also makes the maintenance of large diversion works unnecessary. In view of these facts information was

collected relating to the construction and cost of the devices employed, their efficiency, and cost of operation.

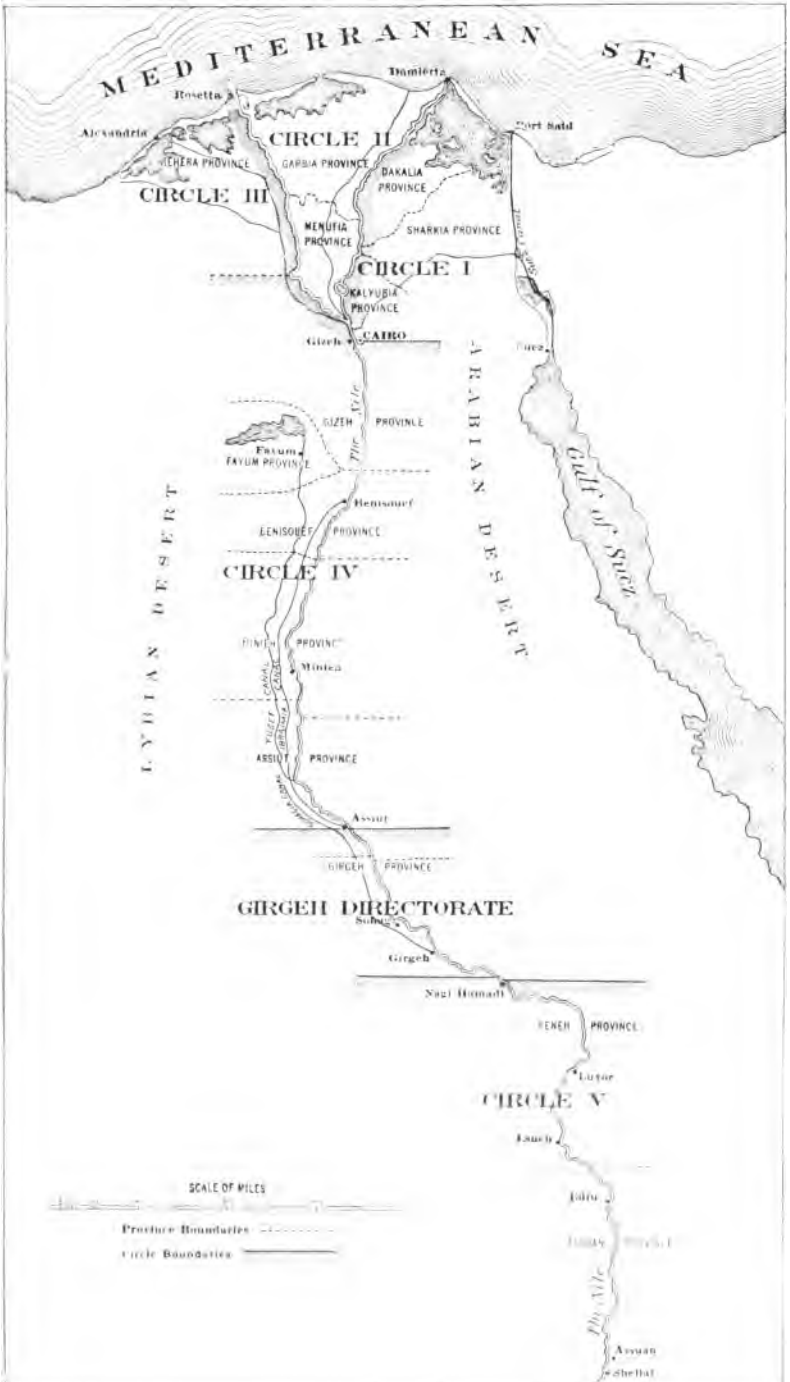
In Egypt as in America the use of water on the higher lands has ruined large areas of lower lands by raising the ground water, and with it the alkaline salts from the subsoil. Work for reclaiming these alkali lands has gone much farther in Egypt than in America, and Egyptian methods were, therefore, studied with much interest.

A GENERAL VIEW OF EGYPT.

Northern Africa would be an uninterrupted desert from the Atlantic to the Red Sea, except for a narrow strip bordering the Mediterranean, if it were not for the Nile. As it is, there is only a thread of arable land in the valley of the river, the surrounding desert being absolutely barren.

Egypt proper extends from Assuan to the Mediterranean. (See map, Pl. I.) South of Assuan is Nubia, which extends as far south as Khartum. The valley of the Nile is very narrow. But little cultivated country is found from Assuan to Luxor; the width of the valley between Assuan and Cairo varies from practically nothing to 9 miles, and there are a number of places where the desert touches the Nile on either bank, as at the point where the Gebel Silsileh hills cross the Nile. Between Edfu and Assuan there are many places where the drifting sands from the desert are encroaching upon the agricultural land. From Assuan to Edfu, a distance of about 90 miles, the agricultural land is about equally distributed on either bank. From Edfu to Erment, a distance of about 80 miles, the agricultural land is nearly all on the western shore, having an average width of 3 miles. From Erment to Assiut, over 200 miles, a large part of the agricultural land is on the left bank. From Assiut to Cairo the agricultural land is practically all on the left bank. At a point about 60 miles above Cairo the valley reaches its maximum width of about 9 miles, near where the Yusef Canal crosses the Lybian Desert into the Fayum. The delta proper begins some 12 miles below Cairo, and is triangular in shape, being nearly 120 miles on each side. The greater part of the irrigable land of Egypt lies in the delta, but only about half of the land that is actually farmed at the present time is found there. The remaining lands are being brought under cultivation by drainage and other reclamation works. The total agricultural area of Egypt is 5,000,000 acres or about four times the area of the State of Rhode Island.

The writer arrived in Alexandria in the early part of December, 1901. An Egyptian winter compares favorably with a Colorado summer. Everything is in summer garb, the vegetation being more attractive than it appears during the preceding hot months. Even the natives prefer the winter season, although they feel the chill of the night air and suffer from an occasional shower.



MAP OF EGYPT, SHOWING PROVINCES AND IRRIGATION CIRCLES.

After passing the custom-house at Alexandria and driving through narrow streets to the railway station the train for Cairo is boarded and soon the country is reached where palm trees wave their tops on either side. Lower Egypt in the vicinity of Alexandria is not attractive. Much of the land needs draining and a large part of that visible from the railway train is devoted to the growing of forage grasses. Open drains can be seen on either side and occasionally large canals parallel the track. The Mahmoudia Canal, which supplies the city of Alexandria with fresh water, lies on the north side of the railway and it is visible a part of the time during the first half-hour's ride toward Cairo. A roadway is provided on the banks of the canal and the native traffic is fully as interesting as the country through which the railway has been built. Long lines of camels loaded with cotton are followed by others carrying huge bundles of cotton stalks to be used for fuel. The stalks completely cover the camels so that it appears as if the burden furnished its own means of locomotion. The sails of the boats on the canal are seen when the banks of the canal are low or where the railway grade is high, and at times a view of the hulls and the cargoes is obtained. Cotton, fruit, straw, sugar cane, and vegetables seem to be the chief articles of exchange. Between 15 and 20 miles from Alexandria the first cotton fields are seen on the south side of the railway. Farther on camels are lying in the fields while the farmer loads on their backs farm products of different kinds in readiness for a trip to some nearby market. The cotton is pressed into bales, which are left on the ground to be carried later to a water front and thence to Alexandria. In quality the cotton is second only to American Sea Island cotton and the United States secures from 40 to 60 per cent of the entire Egyptian staple. The towns and villages are all on higher ground than is the surrounding farming land. This may be due in part to the selection of the site and in part to the gradual elevation of the villages as the buildings crumble and new ones are erected in their places. The markets are well supplied with fruits, among which the mandarin and other oranges seem to predominate. Dates, figs, bananas, and other fruits are common. The cultivated land grows richer as the Rosetta branch of the Nile is approached. The fig tree, the lebbek, the eucalyptus, and several varieties of the palm add much to the beauty of the landscape. Acacia trees of several varieties are seen here and there and the mulberry and numerous kinds of thorn trees abound. Vines of different kinds trail over buildings wherever conditions permit.

The Rosetta branch of the Nile is reached after a ride of nearly two hours. It is 63 miles by rail from Alexandria. The river is broad and is covered with craft of various kinds. Just beyond is the village of Kafr-ez-Zaiyat. The country greatly improves beyond the Rosetta branch of the Nile, and the farming scenes around Tanta can not be

surpassed in Egypt. Farmers are in their fields cultivating the ground and cleaning away cotton stalks and other vegetation of the summer season. Here and there are oxen pulling wooden plows and farmers are cultivating by hand the land which can not be worked conveniently in any other way. Along some of the canals water-raising machines are in operation. Here and there two sturdy men are swinging a basket and lifting water from a canal for the irrigation of nearby farms. (See p. 44.) Herds of water buffalo, cattle, sheep, and occasionally horses can be seen grazing in the fields of clover.

A number of large canals, many of which are branches of the Manufia Canal, which leaves the Nile at the head of the delta, are seen from the train. The Damietta branch of the Nile is crossed, and after passing a few small towns and crossing a deep canal, which has been completed since the occupation by the English, the Pyramids, 20 miles away, come into view, and Cairo is reached.

Many interesting scenes can be witnessed in Cairo itself, showing the methods employed by farmers and gardeners. Between Cairo and Old Cairo to the south are a number of small tracts of farming land where the native may be seen at work. Across the river from Cairo a trolley line runs to the Pyramids of Gizeh. Along this for a distance of 6 or 7 miles one can see farmers working in the fields almost any time. The farms spread out on either side resemble but little those with which we are familiar in the United States. No fences are seen and no houses have been provided on the farms themselves. The farms are narrow, and it is impossible to use a mowing machine or a binder on some of them for this reason. Dwelling houses are found only in the villages, except where perennial irrigation has been practiced for many years.

Early in December wheat and barley are just sprouting from the ground in places while some lands are being prepared for the seed. Clover and beans are usually well advanced. Corn is piled here and there along the levees where it is to be husked during the later winter months. The fields of clover on either side are dotted with buffalo and other live stock. The farmer himself is a picture not to be forgotten. His long-flowing black or white gown, while not appearing to be designed for the convenience of a laborer, lends attractiveness to the farming scenes.

The view from any point along the road to the Pyramids is full of interest. To the east is the village of Gizeh, the Nile, and, beyond it, Old Cairo and the hills of the Arabian Desert on the horizon. Either to the north or south nothing can be seen but green fields, canals, levees, and villages of sun-dried brick, sheltered by palms and other trees. To the west is the Lybian Desert, the Pyramids of Gizeh, and the Sphinx. The latter looks over the farming lands below and across the Nile, as it has for 2,800 years. It is supposed to represent the

ing, Amenemhet III, the great builder and the reformer of the practice of irrigation in Egypt. It seems that the famous monument to him was planned so that it should be a permanent witness of the career of the fellah and of the progress of irrigation.

The fellah, although he has been ruled by one foreign power after another, has been almost as unchanging as his surroundings. Whether from lack of ingenuity or because he is satisfied with the appliances of his forefathers, the Egyptian makes very little progress in the construction or use of agricultural or scientific instruments. The writers of the hieroglyphs on the temples constructed four thousand or five thousand years ago might have received their inspiration from scenes in the fields to-day. The fellah plows his ground with a wooden plow or stirs it with a hoe or with a more primitive wooden implement. (Pl. II.) He cultivates the growing crops with a hoe and harvests them with a sickle or pulls the stalks from the ground by hand. The grain is either beaten out with a flail or trodden and chopped out by means of a wooden sledge furnished with rollers carrying disks and drawn by oxen. Egyptian agricultural methods would not look so much out of place were it not that at the present time considerable areas are owned by foreigners who have adopted modern methods. An improved thrashing machine may be at work in a field adjoining a plat where a native farmer is wearing out the straw in thrashing the grain by a primitive method which antedates biblical times. It is not uncommon to see a steam plow and one pulled by a camel and a buffalo working in adjoining fields. An immense modern steam pumping plant may be operated alongside a shaduf or a sakiyeh, and the native when interviewed will point with pride to the superior machine he employs.

After visiting the great barrage below Cairo and noting how the structure is maintained by the government, how it serves as a bridge across the Nile as well as a diversion work, how well the navigation interests of the Nile and the large canals have been conserved, and how beautifully the grounds of the southern extremity of the delta in the vicinity of the dam have been laid out in parks, the writer made arrangements to visit the Fayum province at the extremity of the Bahr Yusef Canal (the water of Joseph), some 75 miles southwest of Cairo. The province can best be reached by rail, going from Cairo 40 miles up the river to Wasta and there changing cars for the capital city, Medinet el Fayum. The morning fixed upon for the trip happened to be foggy and cold for Egypt. But little could be seen except the country lying near the railroad. Sugar cane, date-palm trees, and wheat fields abound and occasionally fields of clover and beans could be identified. After leaving Wasta it requires a run of only a few minutes to reach the margin of the cultivated lands. Soon the desert was entered and no sign of vegetation could be seen. Along the margin of the valley the hills break off abruptly and the country is rather

rolling, but as soon as one leaves the slope toward the Nile the desert is comparatively flat and uninteresting.

After traversing the desert for about thirty minutes signs of cultivation began to appear, although the land showed that the water supply had not been adequate. As the soil is sandy, much water is needed to maintain plant growth. But few trees have been planted in this district and the houses of the farmers are scattered here and there, indicating that their location had not been fixed by any prearranged plan. As the flood of the Nile does not reach the Fayum, the village life so common in the valley of the Nile is not essential. As Medinet el Fayum is approached the country takes on new life and the soil changes to a black loam which yields all kinds of crops in abundance. The town is situated along the bank of Joseph's Canal, which furnishes the life of the province and adds much to the attractions of the town.

The country around the town is very productive, and affords an excellent opportunity for studying Egyptian agricultural methods. The entire province slopes toward a lake which lies along the margin of the desert to the northwest of the capital. The fall of the country is considerable, enabling the farmer to irrigate his field by gravity, as is done in the United States. Many lifting devices are found along the canals, however, which serve for the irrigation of lands lying adjacent to them. To the east of the town the canal is less attractive than it is within the limits of the capital, because it is more tortuous and the material which has been taken out in cleaning the channel has been deposited in heaps along the banks. The thrifty appearance of all growing crops is sufficient evidence of the fertility of the soil and the effectiveness of the irrigation system. Many trees seldom seen in the valley of the Nile can be found in this province. Among these the olive predominates. Date palms, oranges, and figs are extensively grown and the vine is well represented.

The conditions of the Fayum have changed but little, as far as we have any authentic history, since the time Lake Moeris disappeared to give place to an agricultural community. For over three thousand years the province has been cultivated and the people have enjoyed more of peace and prosperity than have the farmers in the valley of the Nile. The ruins of ancient Crocodilopolis lie to the south and west of the present capital, and to the east on the edge of the desert pyramids and ruins of immense temples are found.

In returning to Cairo the day was clear, and the entire panorama of desert and cultivated land was spread out as the train sped along. Farmers were out in the fields, some plowing with their curious wooden plows, others digging with the hoe, and others clearing the land or cleaning small ditches. Here and there steam plows belonging to some larger plantation took the place of the more primitive native implements. Drainage work was in progress in places, and occasion-

FIG. 1.—PLOWING WITH OX AND BUFFALO.

FIG. 2.—PLOWING LAND WHICH HAS BEEN BAKED BY THE SUN.

CLEANING A LARGE CANAL.

ally a piece of land was being leveled; crude wooden scrapers drawn by oxen were alternately filled from the higher places and emptied into the depressions. Some farmers had finished plowing and were driving oxen attached to heavy framework drags to break the clods and smooth the surface of the fields.

The journey from Cairo to Assuan can be made either by rail or by water. By rail one sees the canals and irrigated fields and the different methods employed in tilling the soil and cleaning water channels. By boat the diversion works at the heads of canals, the water-raising devices and irrigation structures near the river can best be studied. The journey by water has some advantages over the trip by rail. The boats have regular stopping places, where the surrounding country can be studied, and as the valley is in no place more than 9 miles wide, a considerable portion of the farming land between the river and the desert can be examined in a few hours.

Leaving Cairo in the morning by rail, Assuan is reached the next afternoon. The road runs south, on the west side of the river, paralleling the Ibraimia Canal as far as Assiut; it continues then to Nagi Hamadi, 373 miles from Cairo, where the river is crossed. The southern terminus of the road is at Chellal, 6 miles south of Assuan. Probably the most interesting part of the trip, to one making a study of irrigation and agriculture, is between Cairo and Assiut, a distance of 240 miles. The broad Ibraimia Canal parallels the railroad for some distance below Assiut. During the winter it is dry for a short time, when the channel is hurriedly cleaned. Laborers carrying baskets, which are filled by means of the hoe, swarm the banks and bottoms of the canal. The side slopes are formed accurately and smoothed with that instrument in a way seldom equaled in the United States. There are no plow marks along the banks and runways for teams are unnecessary, while the bare feet of the laborers tend to smooth rather than scar the surface of the ground. The material to be excavated has been cross-sectioned and each man or company of men is required to remove a certain volume. (See Pl. III.) The more industrious make the better wages.

The regulating works at Dirut can best be examined by stopping at the station for a few hours. These are representative of the best regulators in Egypt. Two large and two small canals begin at this place. The former are the Bahr Yusef and the Ibraimia canals, while the latter are the Dalgawi and Dirutieh canals. Running direct from the Nile and supplying water during the flood is the Saheliyeh Canal. The masonry works run from the point where this canal enters the channel above the regulators to the Ibraimia, thence to the Dirutieh, thence to the Bahr Yusef, and end just beyond the point where the Dalgawi Canal has its head. The works are substantially built and are maintained in good condition. One man can operate the gates of any

of the canals by means of a traveling winch. On the east bank of the channel, about 500 feet above the entrance of the inlet gates of the Saheliyeh Canal, is a waste gate which discharges surplus water into a channel connecting with the Nile. The Dalgawi regulator has two gates, each nearly 10 feet wide. The Bahr Yusef has five, the Dirutieh has three, the Ibraimia has seven, and the entrance regulator of the Saheliyeh Canal has two gates. The wasteway has five gates. The latter, as well as the regulators of the two large canals, are supplied with locks which permit the passage of such boats as are employed on these waterways.

The Ibraimia Canal will henceforth be supplied at all times of the year from the new headworks at Assiut, which have been built in conjunction with the reservoir work at Assuan and the diverting dam at the former place. The latter structures are described elsewhere in this report.

The farming country becomes narrower as one ascends the river from Assiut. No perennial irrigation is practiced above Assiut except on the lands lying near the Nile, which are served by water-raising devices of various kinds. The Arabian desert breaks off abruptly on the eastern bank of the river in many places, and the principal areas of farming lands are found on the western side of the river.

Large sugar plantations are common, and at the principal towns sugar mills are in operation. Light railways have been built throughout Egypt wherever demand for transportation facilities warrants the outlay. These are narrow-gage roads, and the rolling stock is of the lightest.

The Sohag Canal, which was probably once a channel of the river, irrigates a large area between Assiut and the town of Sohag during the flood of the Nile. In the winter it lies high and dry, while the adjoining farms are green, as a result of inundation. At Dendera, farther up the river, where ruins of the celebrated temple bearing the same name have been found, the agricultural lands showed that a season of adequate water supply had been enjoyed. The temple was nearly buried by the crumbling mud bricks of a village which grew up about it, and has only recently been thoroughly excavated. The farming lands reach to the base of the temple, and during the flood season the water almost touches its foundation. The giant temple of Ammon at Karnak was originally surrounded by a high embankment, but this has been destroyed in places, so that now during the flood water stands to a considerable depth around it. The ruins cover an area 1,800 feet long and 400 feet wide, not counting some of the smaller and less important structures. The farms extend to the original protecting wall of earth. Between Karnak and Luxor can be seen an escape gate which is opened to permit the water of the basin to flow back into the Nile as high water recedes. Across the river the

Colossi of Memnon stand in a cultivated field watered by wells furnished with sakiyehs.

From Luxor to Assuan the valley contains but little of interest. The famous quarries where the Silsileh hills reach the water's edge on either side give one an idea of the immense quantity of stone which has been taken out for all kinds of masonry work. A narrow fringe of palm trees lines the banks of the river in many places, and the area of the agricultural land is limited on either side.

Assuan, lying on the right bank of the river just below the first cataract, is the Mecca of the traveler in Upper Egypt. The Elephantine Island, lying opposite the town, in the river; the rough, sterile deserts on either side; the granite points on land, and rocky islands in the rapid currents of the cataract each add to the interesting features in the vicinity of the town. The granite quarries in the desert to the east and north of Assuan show how that material was taken out in the early days of Egypt, and at the head of the cataract only 4 miles up the river one can see how through modern engineering appliances the same material is now handled. In less than four years the engineers of the Egyptian Government have built a dam containing 1,000,000 cubic yards of granite masonry. Machinery has supplanted slave labor; and where thousands of men were formerly required to transport large volumes of stone from one place to another the task is now easily accomplished by employing great derricks, steam engines, and improved quarry tools.

By the river it is but 4 miles from Assuan to the head of the cataract, where the great dam has been erected. A footpath follows the Nile, another passes through the desert in a direct line, while the railroad runs along a former channel of the river farther to the east. The dam is seen first if one goes by either footpath, while if the train is taken the island of Philae is in view as soon as the traveler alights at Chellal. No one can forget the first glimpse of this island and the temples with which its surface is covered. All other islands in the vicinity of Philae are high and rocky, while this particular one is flat and well adapted for the purpose to which it has been dedicated. Two miles downstream is the dam.

The engineers in charge of the construction of the dam were willing and anxious to explain the construction work in progress and make clear the function of the reservoir when completed. Some of the engineers had been at Assuan from the day the first work commenced. They enjoyed an ideal climate during the winter, but suffered much from the continuous heat of the summer. The thermometer ranges above 100° F. in the shade between the early spring and late fall months. It often reaches 120° and at times 130° during the summer. But little relief is afforded at night, as the granite rocks give off the heat they have absorbed during the day.

Ten thousand workmen were engaged on the construction of the dam during the winter of 1901–2. These men were poorly paid compared with the wages of those employed on similar work in the United States. They furnished their own subsistence and no shelter had been provided for them.

The best view of the dam is obtained from a position on the left bank of the river, just downstream of the structure. From this point its entire length is visible. Over it can be seen the neighboring islands in the river, beyond which is Philae and its ruined temples. In the foreground are numerous islets which break the river into many small waterways.

THE NILE.

The Nile is among the longest rivers in the world, being in this respect in the same class with the Amazon, the Kongo, and the Mississippi, but in discharge it is much below many rivers having shorter courses. The following comparison of the discharges of large rivers shows the relative position occupied by the Nile:

Comparison of discharges of the Nile, Ganges, Irrawaddy, Brahmaputra, and Mississippi rivers.

River.	Length.	Discharge.			Drainage area.
		Maximum.	Minimum.	Mean.	
	Miles.	*Cubic ft. per sec.*	*Cubic ft. per sec.*	*Cubic ft. per sec.*	*Square miles.*
Nile (at Assuan)	3,300	459,000	10,000	128,000	1,300,000
Ganges (British India)	1,557	491,000	36,000	141,000	391,000
Irrawaddy (Burma)	2,532	[a] 1,000,000	[a] 84,000	350,000	150,800
Brahmaputra (British India)	1,700	1,800,000	146,000	520,000	361,300
Mississippi (at St. Louis) [b]	4,200	994,000	33,000	126,000	1,226,400

[a] Estimated. [b] Head of Missouri to mouth of Mississippi.

The White Nile rises in Lake Victoria, in central Africa, and flows northerly, emptying into the Mediterranean, 3,300 miles from its source. From Lake Victoria to Khartum, where it unites with the Blue Nile, is a distance of 2,100 miles. The only tributary flowing into the Nile below the junction of the two main feeders is the Atbara River, about 190 miles farther north. Both the Atbara and Blue Nile rise in the Abyssinian Mountains and flow northwesterly. From the point where the Saubat River joins the White Nile, 2,370 miles from the Mediterranean, only two tributaries add to its discharge, and for more than 1,600 miles the river passes through an absolutely barren country. Even after it enters Egypt the width of the cultivated land can almost be disregarded in comparison with the broad expanse of desert on either side.

High water of the White Nile appears during June, and the flood does not recede until October. It furnishes a more uniform flow to the irrigators of Nubia and Egypt than any other tributary. It derives

its supply from the heavy rains in the equatorial regions where it has its source. The high-water season of both the Blue Nile and the Atbara begins with July and ends with September. These two streams furnish nearly all of the sediment which has built up the valley of the river in Egypt and maintained the fertility of the soil. The effect of the high water from all sources is felt at Cairo soon after the 1st of August, but owing to the demand for water in upper Egypt during the late summer and early fall months extreme high water does not reach Cairo until toward the end of September, when the basins have discharged into the river.

While the Nile varies each year in discharge it is a singularly steady stream, and in this respect is unlike the rivers with which we are familiar. It has but one high-water season each year, and this begins and ends so regularly that irrigators know when to prepare for the flood. Although the stream is remarkable in this respect, its variations in discharge in different years affect agriculture greatly. During years of low Nile large areas go unirrigated. In average years the Nile furnishes sufficient water to bring prosperity to Egypt. Once in fifteen or twenty years it is unusually high, when large areas are devastated by floods. If a sudden rise should occur in the Nile, as so often happens in many of our Western streams, it would be a great curiosity to the natives.

The accompanying chart (fig. 1) makes a comparison between the discharge of the Nile at Assuan and of the Mississippi at St. Louis. It will be seen that the discharge of the Mississippi is very irregular. High water may appear at St. Louis at any time between April and June, and this maximum discharge may range from 250,000 to nearly 1,000,000 cubic feet per second. The maximum discharge of the Nile varies from 300,000 to 420,000 cubic feet per second. If the Nile varied as the Mississippi does at St. Louis, agricultural Egypt would soon cease to exist, unless the great volumes of water which would descend at flood times could be stored and the flow of the river equalized.

Fig. 2 shows the relation between the discharge of the Nile at Assuan and of the Missouri at Kansas City for the four years beginning with 1897, giving the maximum, minimum, and mean yearly discharges for these four years. Both streams flow through arid countries. The Nile rises in a region of tropical rains, although a considerable portion of its supply comes from the Abyssinian Mountains and the ranges of central Africa. The Missouri has its source in the snow-covered Rockies. It will be noticed that the high-water period of the Missouri may occur at almost any time between the middle of April and the 1st of July, while the Nile reaches its maximum near the 1st of September. The discharge of the two streams is about the same during January and February and during the first

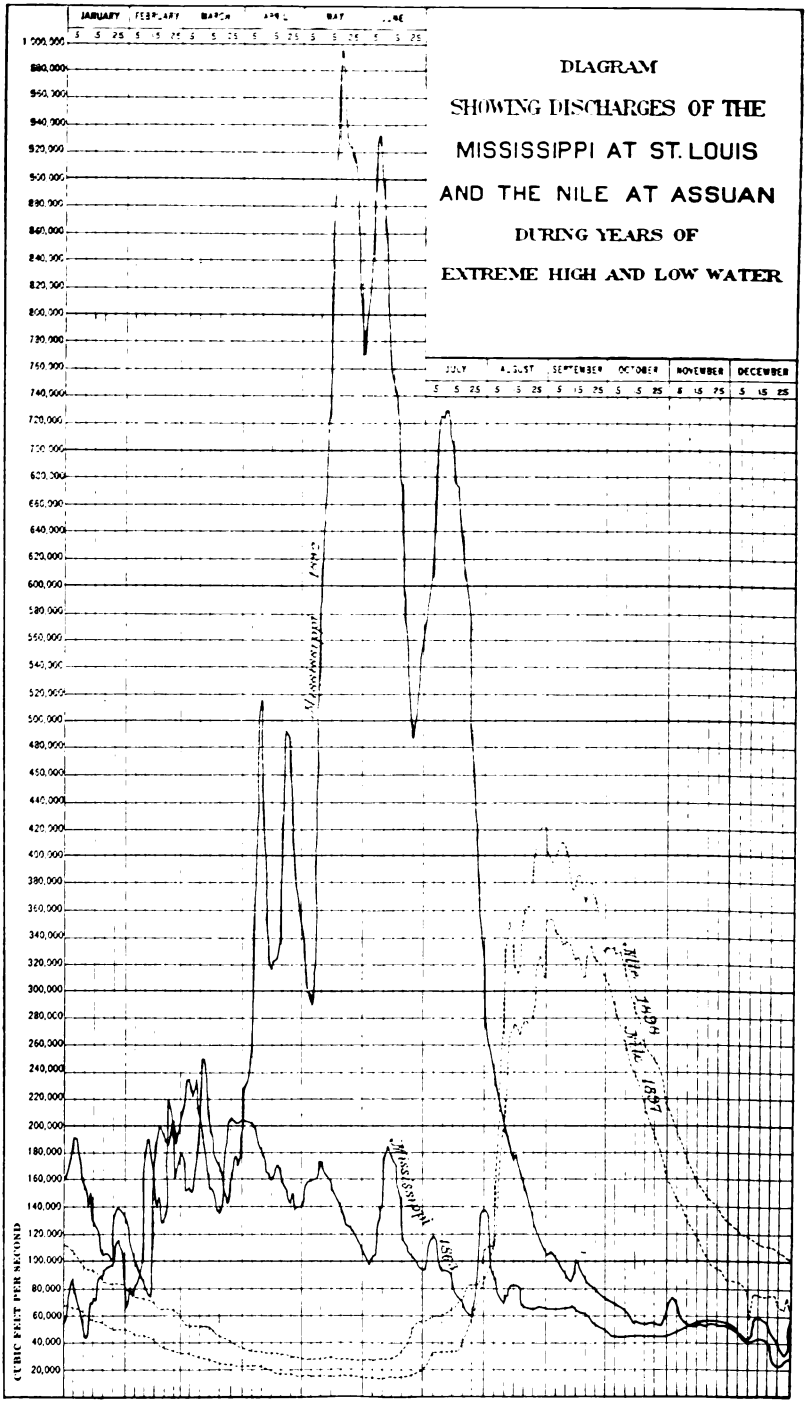
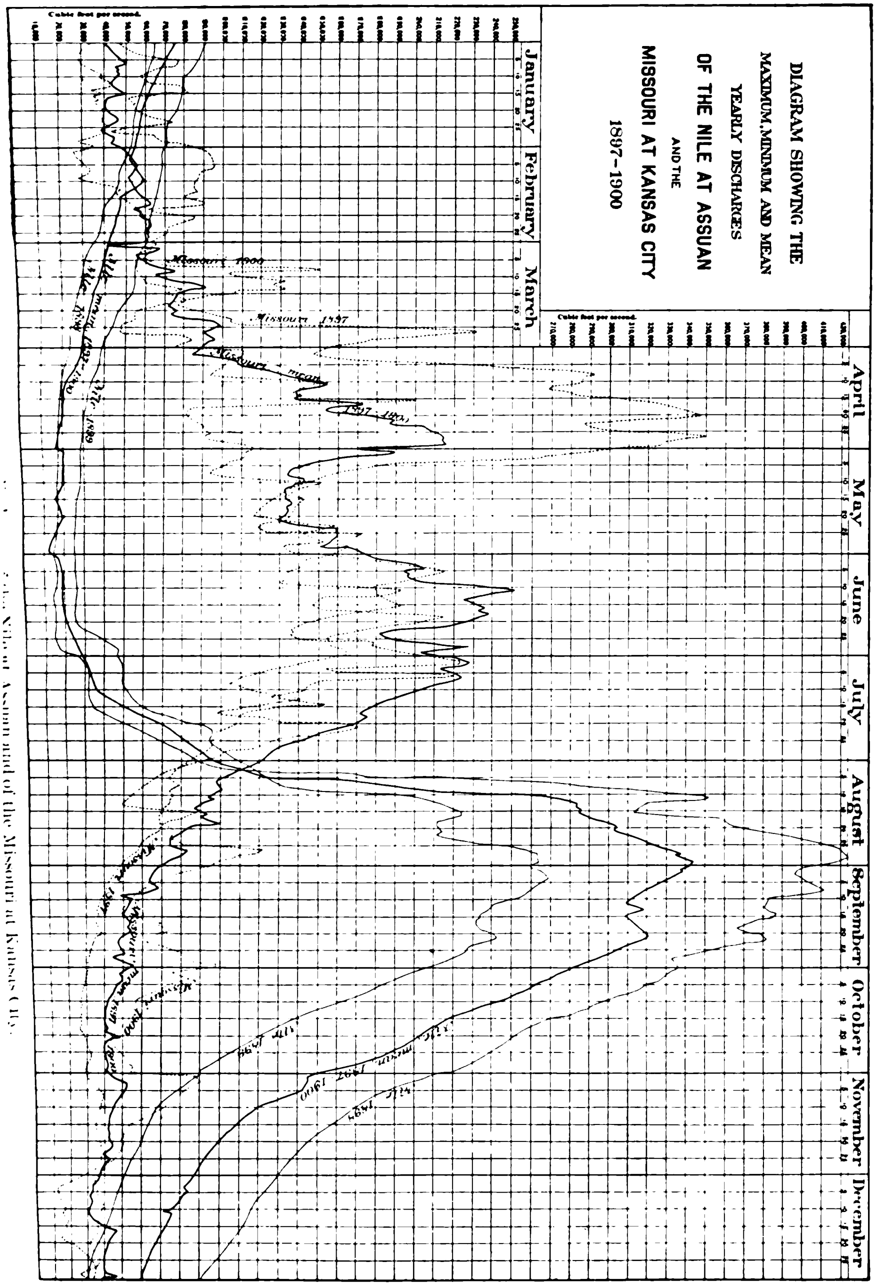


Fig. 1.—Diagram showing discharges of the Mississippi at St. Louis and of the Nile at Assuan.

part of August. It will be observed that the discharge of the Nile is comparatively uniform, while that of the Missouri is exceedingly



irregular. The absence of great fluctuation in the discharge of the Nile can probably be explained by the fact that there are but few

tributaries to the main stream and no local precipitation in Nubia or Egypt.

The ancient Egyptians worshipped the Nile and the sun. All benefits came from these two sources. The inscriptions on many of the temples show the Nile in different phases of its discharge, and many of the scenes pictured there represent the rulers or priests navigating the river. Unfortunately, the tourist seldom sees the Nile in flood. Instead of a gigantic river he sees a sluggish stream of muddy, uninviting water. Its channels are filled with many sand bars. Its banks may be protected by riprapping; they may be rocky or sandy to the water's edge, or supporting a luxurious growth of wheat, clover, or beans. As the river falls crops are planted wherever possible to the water's edge until extreme low-water level is reached. The tourist observes shadufs and other water-raising devices by thousands, but unless he travels otherwise than by boat he has but little opportunity to examine these curious devices for carrying water over the high banks of the Nile, nor does he see much of the land which is watered in this way. He often leaves Egypt without understanding why the Nile should be known as the Father of Rivers and one of the most remarkable in the world. To an American it looks like the Missouri below Omaha at low water. The similarity would be even more striking if the bluffs bordering the Missouri were barren sand hills instead of being covered with vegetation.

The low-water period of the Nile continues until the middle of July. The critical season is between the middle of May and the middle of July. The sun shines from a cloudless sky and the air is filled with dust. Land not perennially irrigated[a] is cracked with heat and thoroughly sun baked. Both man and beast suffer for water except where the Nile, the perennial canals, or wells can be easily reached. Even the branches of the Nile in the delta are practically dry in many places, the water all being diverted at the barrage or pumped from the channels of the river below this structure. During the first part of July all are anxiously awaiting the first appearance of high water. About the 12th or 15th of August the basins of Upper Egypt begin to receive water. The canals for perennial irrigation in both Upper and Lower Egypt are then running bank full and everyone is irrigating the crops so lately threatened with drought.

About the 1st of September the Nile is a mighty torrent, having increased from 12,000 cubic feet per second to 400,000 cubic feet per second or more. Upper Egypt, with the exception of the land perennially irrigated, is a lake dotted with island villages for thirty to forty-five days. After thirty days have expired people are anxious for signs of retreating waters and eagerly await reports from Assuan and other

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[a] Lands along deep canals which always carry water are irrigated throughout the ear, hence the terms "perennially irrigated," "perennial irrigation," etc.

places. It is believed that if the water stands on the land more than forty days insects will be plentiful and crops will be partially destroyed. By prolonged high water the planting season is much delayed and the harvest extended into the hot spring months, which greatly reduces the yield. The basins, however, can not be drained until the Nile begins to fall. During all this time the levees must be watched and an army of men working without compensation is called out for this duty. About the 1st of October the flood is generally over and the basins begin to empty. This is not only a difficult operation in itself, but the volume of water turned back into the Nile causes high water on the lower reaches of the river and lengthens the period during which the banks have to be guarded. In the delta the Nile runs above

BANK OF RIVER

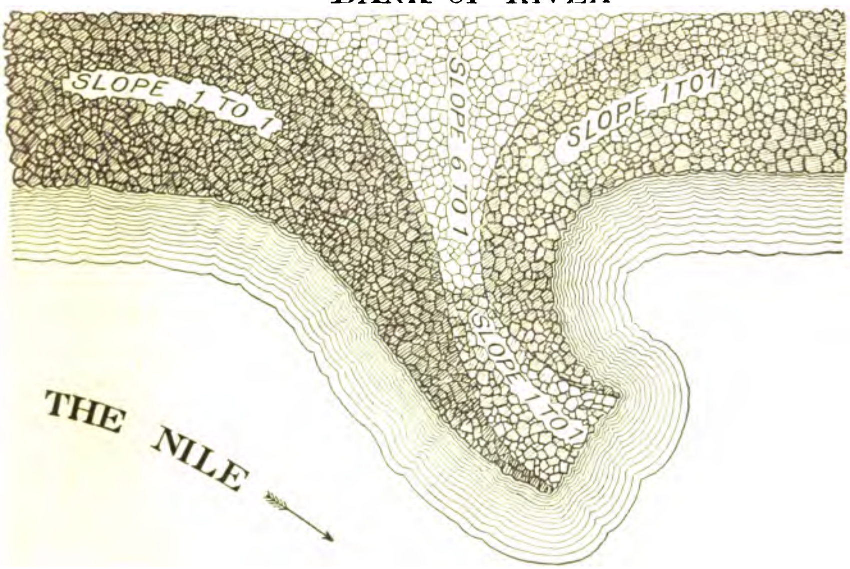


FIG. 3.—Spur to prevent erosion of river banks.

the level of the surrounding agricultural lands and a breach of one of the embankments means an immediate overflow of the neighboring country.

Changes take place in the channel of the Nile during each season of high water. Often the current will change, and where there had formerly been a gradual slope and considerable agricultural land a steep, caving bank will remain. The lowlands and the banks of the Nile which are farmed each year vary considerably in area from one season to another. The agricultural land adjacent to the river is perennially irrigated, and therefore highly productive. In addition, the Nile banks are lined with buildings and expensive pumping machinery. To protect the land and improvements the government

must either build a masonry wall or reduce the slope and riprap it. It is quite common to put spurs in the banks some distance above the points threatened to throw the current farther out in the stream. This is often a dangerous expedient, as the current thus deflected may do considerable damage at other points. Fig. 3 shows one of these spurs constructed by the government.

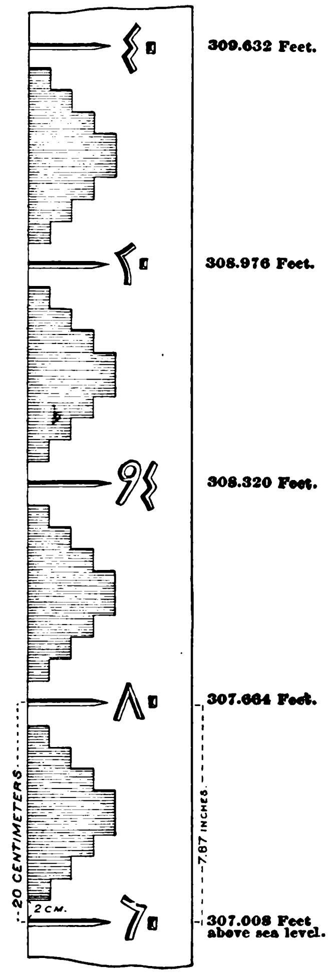


FIG. 4.—Nilometer on the Elphantine Island.

NILE GAGES.

Much has been written about the flow of the Nile, yet it has never been carefully measured until recently. Although Nile gages, now known as "nilometers," were established at an early date, the relation between the gage heights and the discharge was never determined until during the last half century. The measurements first made, even by persons qualified for such work, were rough and can be regarded as only approximate. The use of the current meter has finally permitted accurate gagings to be made, and it will doubtless not be long until enough of these have been taken to give value to the gage heights already recorded.

On many of the rocks along the Nile in Nubia extreme high-water levels have been recorded. Such marks were doubtless the earliest gages of the Nile. During the past few years some old gages have been discovered at Assiut and other points along the river. The most interesting and among the most ancient of the gages are on the island of Philae. The two which can be seen to-day are on the west side of the island. They consist of a narrow stairway leading by a short subterranean passage from the surface of the ground on the island to the river. The gages are placed on the walls of this passageway and are in sections of 3 or 4 feet each. The ancient gage is graduated in cubits or pics and kirats. On the Nile gage toward the south end of the island of Philae there are a number of different scales, the most modern one being graduated in meters and centimeters, similar to the gage on Elephantine Island, as shown in the accompanying cut (fig. 4).

Instead of taking the bed of the river as the zero of the scale, it is referred to mean sea level at Alexandria.[a] It is impossible, therefore, to tell the depth of the water by reading the scale. The gage on the south end of Elephantine Island is of the same character as those on the island of Philae. The modern gage is carefully constructed, being inscribed on pieces of white marble. The gages at Philae are the most reliable, as the channel of the river there is composed of granite, and from the records of a great many years it is found that the average heights of the river have varied but little. The gages on the Lower Nile are of little value in comparison, as the bed of the river is constantly changing.

By far the most celebrated of the gages on the Lower Nile is the one on the island of Rhoda. The graduations are on a pillar which stands in the center of a well, the bottom of which is connected with the Nile by a passage. This column is of stone, octagonal in cross section, and the well in which it stands is about 16 feet square. The nilometer is graduated in pics and kirats.

At the present time the irrigation engineers depend for their first news regarding the stage of the Nile on telegraphic reports from Khartum. The people, however, look to Assuan for their information and are scarcely satisfied until reports are received from that place. From approximate gagings made of the Nile at Assuan the writer has prepared a rating table, from which the yearly discharges of the river have been computed, as shown in figs. 2 and 3. These diagrams are trustworthy only in so far as the gagings are assumed to be correct.

The English engineers have established gauges at a number of points along the Nile above Assuan, among which are those at Khartum, Berber, Wady Halfa, and Lake Victoria. From the reports received from these gaging stations the engineers know approximately what kind of a flood to expect each year, and the irrigator is advised accordingly.

AGRICULTURAL SEASONS.

There are three agricultural seasons in Egypt. The land not receiving perrennial irrigation can take advantage of but one. This begins as early as the middle of October and ends with March. The crops grown then under the basin system are sown immediately after the subsidence of the flood, hence the time of planting depends upon when the fields become dry enough for the seed (Pl. IV). The lands in southern Egypt are generally ready for the seed about the beginning of November. In the Delta crops are often planted as late as the 20th of December. Wheat is the principal winter crop, although clover,

[a] In the same manner the height of a dam or other structure is usually given by referring to the actual elevation of its base and top above sea level.

barley, beans, and many other products are quite commonly raised. The ground is seldom plowed before the wheat is planted. The seed is scattered over the still moist soil by hand, and it is either tramped into the ground by the cattle or pressed in with a primitive wooden roller. Sometimes the ground is beaten with a piece of wood and the grain actually driven into it. The harvest in extreme upper Egypt begins in February and is in progress down the river until the middle of April. In upper Egypt the winter harvest is the most important of the year because a large part of the land there depends wholly upon the ancient system of flood irrigation.

The summer crops are grown between April and August (Pl. V). However, a great many crops are planted in April and May which are not harvested until the following fall or winter. Among these are cotton, sugar cane, and rice, the most valuable crops grown in Egypt. Rice is generally planted in May and is not harvested until the following November. During exceptionally dry seasons a different variety, which ripens in from seventy to one hundred days, is planted quite late in the summer. Owing to the short time required for its growth it is known as sebani rice, meaning seventy-day rice. Cotton is sown in April and picked in November or December. Sugar cane is planted about the same time, and harvested in the following January and February.

The third season has a length of about eighty days, running from August to October and sometimes until November. During this time considerable sorghum is raised, the stalks of which the natives eat. Corn is the chief crop grown, and is second only to wheat among Egyptian cereals in yield. It is probably the most valuable crop to the poorer classes. As soon as it ripens it is cut or pulled up by the roots and piled on the levees, where the stalks dry thoroughly and where the corn is husked. The corn on the ears is then piled on the ground where the earth is firm and the grain is beaten from the cob by heavy sticks in the hands of the farmers. (Pl. VI, fig. 1.) The corn is next ground or crushed and bread is made directly from it, or it is mixed with bean flour before being prepared for food. Wheat is thrashed by a method almost as crude. A sledge furnished with rollers carrying metal disks is pulled by oxen, which travel around a stack of wheat until the straw is thoroughly chopped and the grain is separated from it. (Pl. VI, fig. 2.) The whole mass is then tossed in the air and the wind blows away the lighter material while the grain falls to the ground. This latter process is very tedious, as the straw has to be handled many times before the grain is all separated and cleaned.

FIG. 1.—IRRIGATION BASIN NEAR PYRAMID OF GIZEH.

FIG. 2.—IRRIGATION BASIN WEST OF CAIRO, WATER RETURNING TO NILE IN CHANNEL

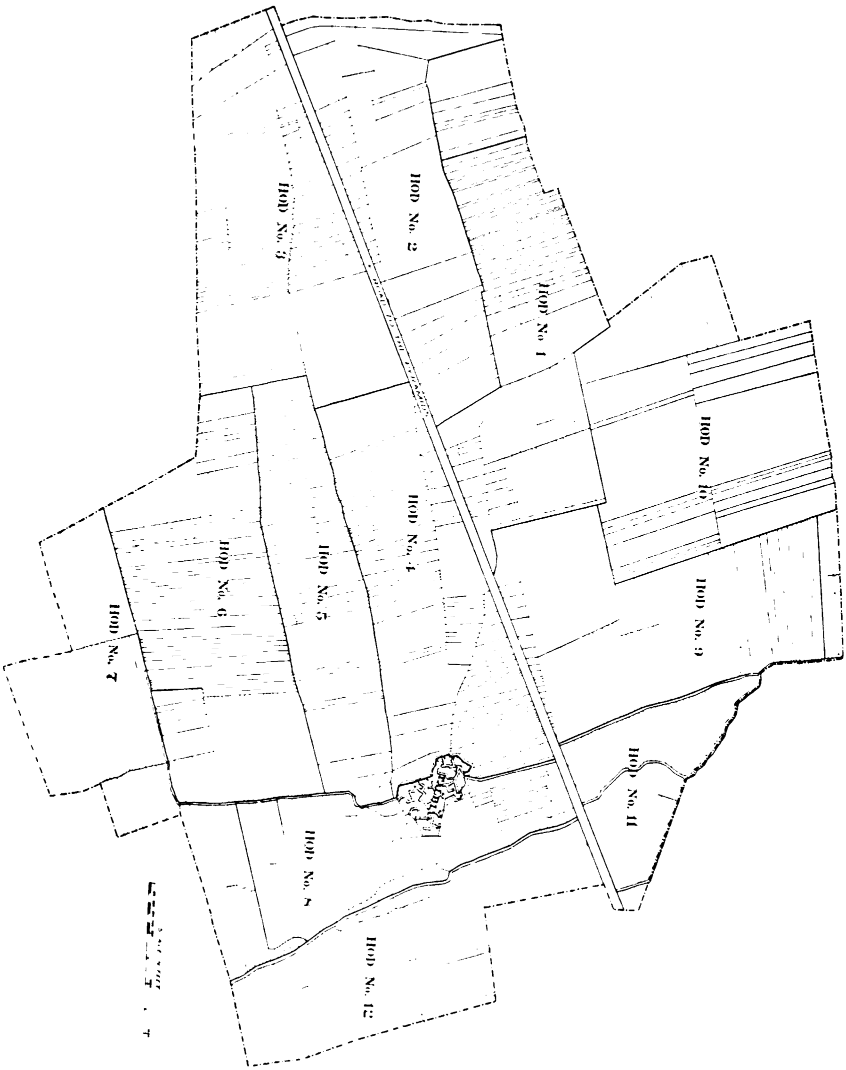
FIG. 1.—IRRIGATING STRAWBERRIES.

FIG. 2.—PERENNIAL IRRIGATION; WHEAT FIELD UNDER CHECK SYSTEM OF IRRIGATION.

FIG. 1.—THRASHING INDIAN CORN.

FIG. 2.—THRASHING WHEAT.

PLATE VII.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HOD No. 7
HOD No. 8
HOD No. 9
HOD No. 10
HOD No. 11
HOD No. 12

FARMS AND VILLAGES.

The term "village" as used in Egypt refers generally to an area of land surrounding and including a town. The farmers have their dwellings in the towns. In the portions of Egypt subject to inundation they are obliged to retreat to the towns during high water. A frontage on the river or other source of water supply is always desirable and these channels are generally boundary lines of farms, the dimensions of which are as unusual as the tools used in cultivating the ground. To enable the greatest number to enjoy the advantages of a water front the width dimension of the farm usually lies along the river or canal. Where water channels do not exist it has become the custom to establish a few lines by permanent monuments. These lines then become the end boundaries of the farm. When a small area is sold its length is the same as that of the original tract and its width is laid off along the lines fixed by permanent monuments. As the area owned or cultivated by each fellah is small, their farms are long and narrow. A square piece of land containing the same area could be worked to much greater advantage.

The accompanying map (Pl. VII) shows the subdivisions of the farming lands of the village of Talbia, near Cairo. The holdings are small in the neighborhood of this village and the land is quite productive. The areas of ten farms, selected more or less at random, ranged from 0.02 to 1.04 acres.

Any small district throughout which the productiveness and therefore the rate of taxation is unusually uniform is known as a hod. The farms of each hod are numbered independently. The official records therefore may refer to farm No. 10, hod No. 6, of the village of Talbia. The maps compiled from government surveys show the farms and hods with their numbers, permitting any particular farm to be identified. Fences are not provided along farm boundaries, as they would occupy too much land.

In the surveys for the finance ministry, villages are mapped independently. It is almost impossible to make up from these separate surveys a general map showing a number of villages, as the boundaries of the villages are irregular and discrepancies always occur in approximate work of this kind. A survey of the boundary between two villages defined by a canal or other water course may be made during the season of high water. At the time it may be impossible to locate the water channel accurately on the map. If the adjoining village be surveyed during low water, it is easy to see that maps made from the surveys would not fit when applied to each other. Outside of these surveys, the Government possesses little information regarding the topography of the country.

Under the French occupation some general surveys were made, but no monuments were established. The English engineers are making

a survey of Egypt and are establishing monuments in some cases. It is doubtful whether these will have any great permanent value as they are not tied to guide meridians or standard parallels. The lack of monuments in the surveys of the villages makes it necessary for the farmers in the districts inundated to resurvey their lands after each subsidence of the water. A few permanent monuments may always be found in the villages and from these the rest of the land is laid out.

The work is repeated until a majority are satisfied that the land has been properly measured. It would cost the farmer only 5 or 10 cents per stone to establish permanent monuments at the corners of his farm, but so fixed has become the custom of remeasuring the land each year that it is preferred to a more convenient system.

English engineers in the survey department are handicapped not only by their inability to secure the best kind of assistance in the field, but by existing surveys recognized by the native farmer. His ancestors measured land to their satisfaction, and he is content to follow their example, not only in the surveys but in the computation of field

FIG. 5.—Diagram showing inaccuracy of land measurements.

notes. The Egyptian has a special formula for computing the area of land to which he adheres with a steadfastness which would be praiseworthy in a better cause. For instance, when a triangular piece of ground is to be surveyed, only the lengths of the sides are taken. To compute the area the lengths of two adjacent sides are added, the sum is divided by 2, and this quotient is multiplied by the length of the remaining side divided by 2. If the figure happens to be a quadrilateral, the two opposite sides are added together and divided by 2 and the quotient is multiplied by the two remaining sides added together and divided by 2. Putting the formula in figures and referring to the accompanying diagram, the inaccuracy of the method may be plainly seen (fig. 5).

$$\text{Area of triangle} = \frac{ab + bc}{2} \times \frac{ac}{2}$$

$$\text{Area of quadrilateral} = \frac{ab + cd}{2} \times \frac{ac + bd}{2}$$

The formula for the area of a triangle never gives accurate results. The formula for a quadrilateral is correct only when the figure is a rectangle.

A few years ago an investigation was made to determine the average size of the land holdings in Egypt. At the same time considerable information was gathered regarding the number of farms and as to whether the owners were natives or foreigners. It was found that foreigners owned 5,139 farms, having a total area of 233,838 acres. The average size of these farms was therefore 45.87 acres. There were 22,699 farms owned by natives who, having considerable influence, had secured titles to large areas under the conditions prevailing prior to the occupation of the English. These people held 1,420,187 acres, the average size of the holdings being 62.59 acres. There were 502,810 farms belonging to the peasantry. They owned 2,752,500 acres, making the average size of their holdings 5.47 acres. The total number of farms in Egypt was 530,548. The total cultivated area exclusive of state lands and the area administered by the Daira Sanieh was 4,406,525 acres. The average size of an Egyptian farm was therefore 8.3 acres. The total population of Egypt at the time the census was taken was 6,754,050, so that one person in twelve was a landowner, while 80 per cent of the landholders owned less than 10 acres each.

COST OF RAISING CROPS AND VALUE OF FARM PRODUCTS.

The cost of raising different crops, as well as the yield of the same, varies greatly throughout Egypt. Crops grown in the winter on lands employing the basin system of irrigation can be matured much cheaper than those grown under perennial irrigation where water must be lifted. In the best agricultural districts of Upper Egypt sugar cane is the most valuable crop. In preparing the ground for seed and sowing the same an outlay of about $7 per acre must be met. The seed costs from $10 to $12 per acre, irrigation about $10, cultivating and harvesting $14, making the total cost per acre amount to $40 or $45 per acre. If the land requires fertilizers the cost of these may make the yearly expense $2.50 higher. The yield of sugar cane averages about 32 tons per acre, which is worth $128. The net profit from an acre of sugar cane is, therefore, between $80 and $85 per acre. If the land is rented the tenant probably pays from one-third to one-half of the crop to the owner. The landowner pays between $5 and $10 in taxes each year on such land. The cost of raising cotton in Upper Egypt is about one-third as much as for raising sugar cane, while the net profit approximates $50 per acre, or about five-eighths as much. The cost of raising other crops runs from $1 to $6 per acre in Upper Egypt. The principal crops grown there in order of their importance are sugar cane, cotton, wheat, Indian corn, millet, vegetables, beans,

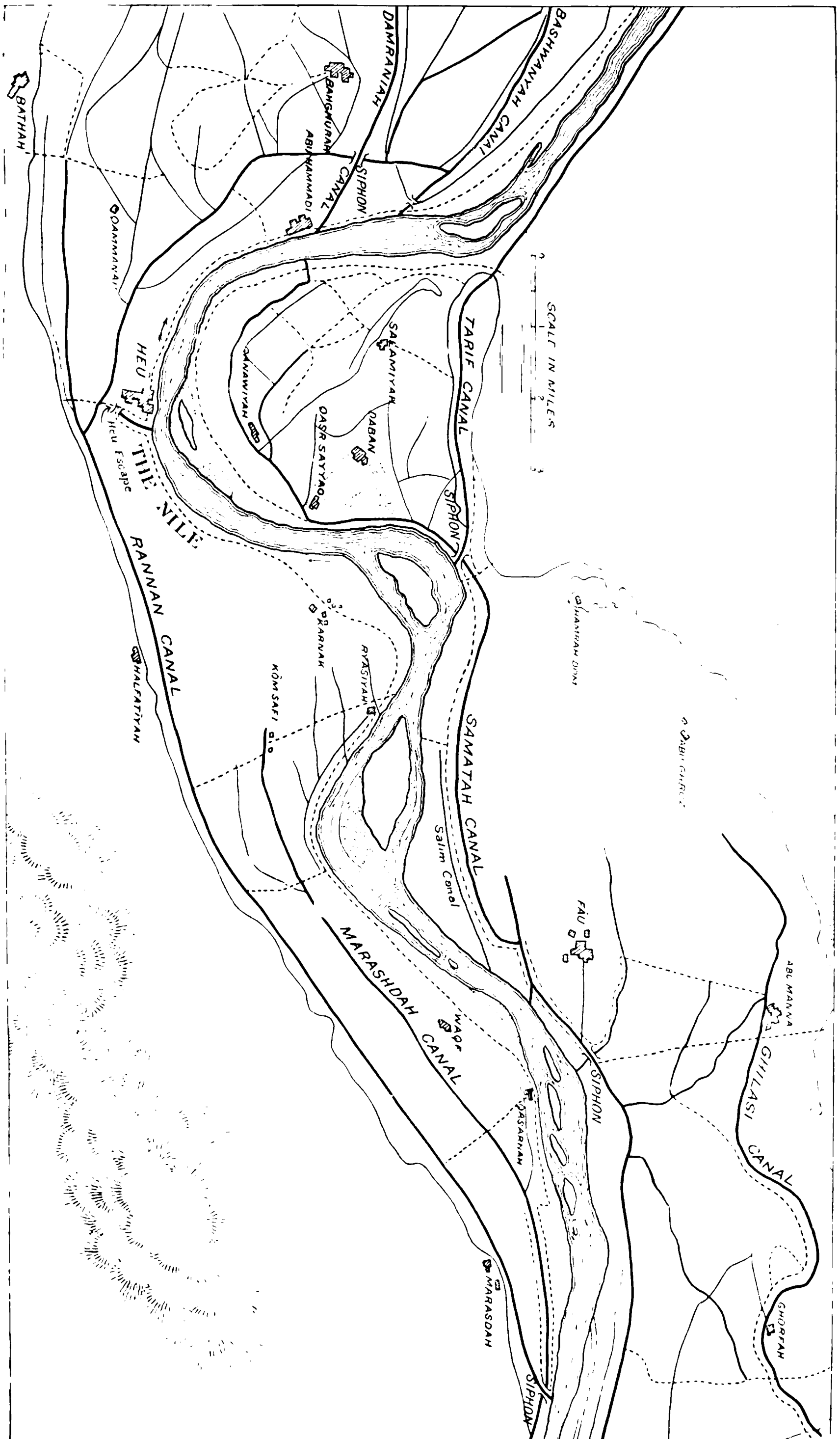
and clover. Some fruit is grown, especially in the Fayum, where oranges, lemons, limes, olives, etc., are quite common.

In the southern half of the delta sugar cane is grown principally for eating purposes. The cost of raising the cane there is about the same as in Upper Egypt, but the net profit derived from the ground is about twice as great. Fruits of different kinds are among the most profitable crops of this portion of Egypt. The date is grown extensively, and a special tax is levied on this fruit. When a tree is cut down another must be planted in its place. The government revenue from an acre devoted to raising dates runs from $10 to $45 per acre. The cost of cultivating the ground approximates $50 per acre, while the net profit is about $150 per acre. Considerable land is devoted to the growing of different vegetables. The cost of raising vegetables averages about $15 per acre, while the net profit from the ground is about $55 per acre.

While some cotton is grown in the northern half of the delta, this portion of Egypt must be regarded as essentially a rice district. The net profit from the cotton fields is about $25 per acre, while rice pays from $6 to $18 per acre only. Much of the rice grown in this portion of Egypt is planted on ground which is being reclaimed and put in condition for the production of more valuable crops. Indian corn, barley, wheat, and clover are the other crops grown in the northern portion of the delta. Some fruit is produced in the vicinity of the towns and villages.

DEVELOPMENT OF EGYPTIAN IRRIGATION.

Originally all of the agricultural lands along the Nile, except a narrow strip, depended upon the flood of the river for irrigation. But one crop could be grown each year, and this in the winter time. During the remainder of the year the land remained fallow. Most of the large canals were built during the twelfth dynasty (2200–1600 B. C.). Levees were built along the Nile and the farming land was divided into basins, which were filled with water from canals when the river rose to a marked place at the head of the El Khalig Canal at Cairo. As soon as this height was reached word was sent throughout Egypt: the temporary earthen embankments at the heads of the canals were then broken, and the water ran to the basins. If the Nile failed to rise sufficiently high to furnish water for the basins, considerable suffering resulted. If the river was too high, embankments would break, levees would be washed away, and widespread desolation would result. It was not only necessary to fill the basins with water, but the water had to be red with silt from the mountains and plains of Abyssinia. If the land failed to receive the deposit of red mud, the yield would be reduced. Emptying the basins was even more difficult than filling them. The lower basins had to be emptied first, or, if good



Map Showing Irrigation Works in a Portion of the Province of Keneh.

FIG. 1.—CAMELS CARRYING RUINS OF VILLAGE TO BE USED FOR FERTILIZER.

FIG. 2.—CLEANING A SMALL CANAL.

regulators were provided between them, the water from all could be run at once. If one of the embankments of an upper basin broke, it meant devastation to everything below. The basins could not be emptied until the Nile began to recede, and there was nearly as much danger in having the flood continue too long as in not having a sufficient supply of water. This system has survived to the present time. While the basins first laid out were crude, they have developed after many years of experience into well-regulated systems. Expensive regulators have been constructed and canals have been made large enough to carry water to supply the land they were intended to serve. The escapes into the Nile have been perfected. The land near the Nile is above the level of the adjoining farms (fig. 6). For this reason it is difficult to fill the basins near the Nile embankments. The grade of the Nile varies from one-half to one-third of a foot per mile. Owing to this slight fall the canals have to be quite large, because their grade must be less than that of the river. Even under the most favorable conditions they can not gain more than a small fraction of a

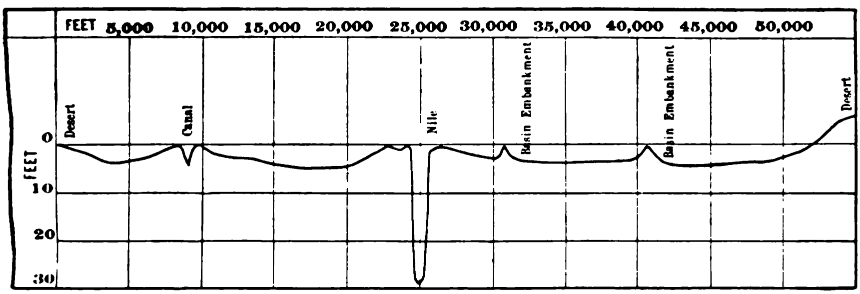


FIG. 6.—Typical cross section of the Nile Valley.

foot per mile over the river. When a canal reaches the edge of the desert, or, in other words, covers all of the arable land except the Nile berm, it follows the desert until a new canal is taken out, when the first canal siphons under the new one and covers the high land along the river. The second canal proceeds in the same way and siphons under the third. By this system canals can be made to serve the entire area of agricultural land.

Pl. VIII shows a portion of the Nile Valley in the province of Keneh where the river has a general course from east to west. The strip of irrigated land, bounded by right lines, is in no place over 7 miles wide. It will be seen that the Rannan Canal heads at the right, on the south bank of the river, and that the Marashdah Canal siphons under it just below the point of diversion. The latter canal is on a higher line at their intersection and waters the elevated lands along the berm of the Nile for 12 miles below the siphon. The Rannan Canal continues westerly and soon covers all the land to the border of the desert. Just

before it reaches the Heu Escape, which was built to empty the basins above the south side of the river, it divides, one branch serving the high lands along the desert and the other furnishing water to the basins near the Nile. The basin boundaries are shown by dotted lines. The canal and basin system on the north side of the river are also shown. There are small areas here and there in Upper Egypt which are irrigated from wells, but the larger part of the land is still flooded by the Nile and enriched by its sediment, as it has been for thousands of years past.

But this ancient system of irrigation has one great drawback—but one crop can be raised each year, while all other conditions, except the water supply, favor the raising of several crops. Recognizing this, Mohammed Ali in 1837 began reforms looking to the supplying of water to crops during the whole year. The great barrage at the head of the delta was begun in 1843, as a part of the plans for perennial irrigation. The first perennial canals were in the delta and the Fayum, but the system is being gradually extended to the south, the country between Cairo and Assiut being in a state of transition, and the recent great works at Assuan and Assiut being for the purpose of increasing the area supplied with water throughout the year.

The returns from the soil have been greatly increased by the adoption of perennial irrigation. However, this system is accompanied with certain drawbacks. Only by the old flood-irrigation system can the land receive any considerable amount of rich Nile silt, and when two or three crops per year are taken from the ground the soil deteriorates quite rapidly. Artificial fertilizers are necessary, and these are expensive in Egypt. The principal supply of fertilizer at present is from the ruins of old towns and villages. This is simply the Nile deposit which has been used in times past in the manufacture of brick for the construction of houses, impregnated with more or less fertilizing matter derived from the village wastes. Long lines of camels may be seen carrying this material to the farms. (Pl. IX, fig. 1.) Sometimes it is to be transported 10 or 15 miles or farther, each camel carrying about 600 pounds, distributed between two wicker panniers thrown across his back.

THE CANALS OF THE NILE VALLEY.

As has just been pointed out, there are at the present time two kinds of canals in Egypt. First, the perennial canals of the delta, which date from the time of Mohammed Ali; the Ibraimia canal, and the canals of the Fayum, built like those in the United States, with the idea of receiving water throughout the year or whenever crops need irrigation. The water of these canals generally runs below the level of the irrigated lands. Second, the flood canals, for filling the basins in Upper Egypt, which leave the river on a much higher level relative to its bed.

In the province of Assuan there are two canals on the left and four on the right bank of the river. These supply all the basins in that province during the flood season. The only area watered throughout the year is a narrow strip bordering the Nile and other water courses carrying a supply at all times. In the province of Keneh there are 8 canals taking water from the west bank of the river and 13 diverting water from the east bank. In the province of Girgeh 11 canals divert water from the left and 5 from the right bank.

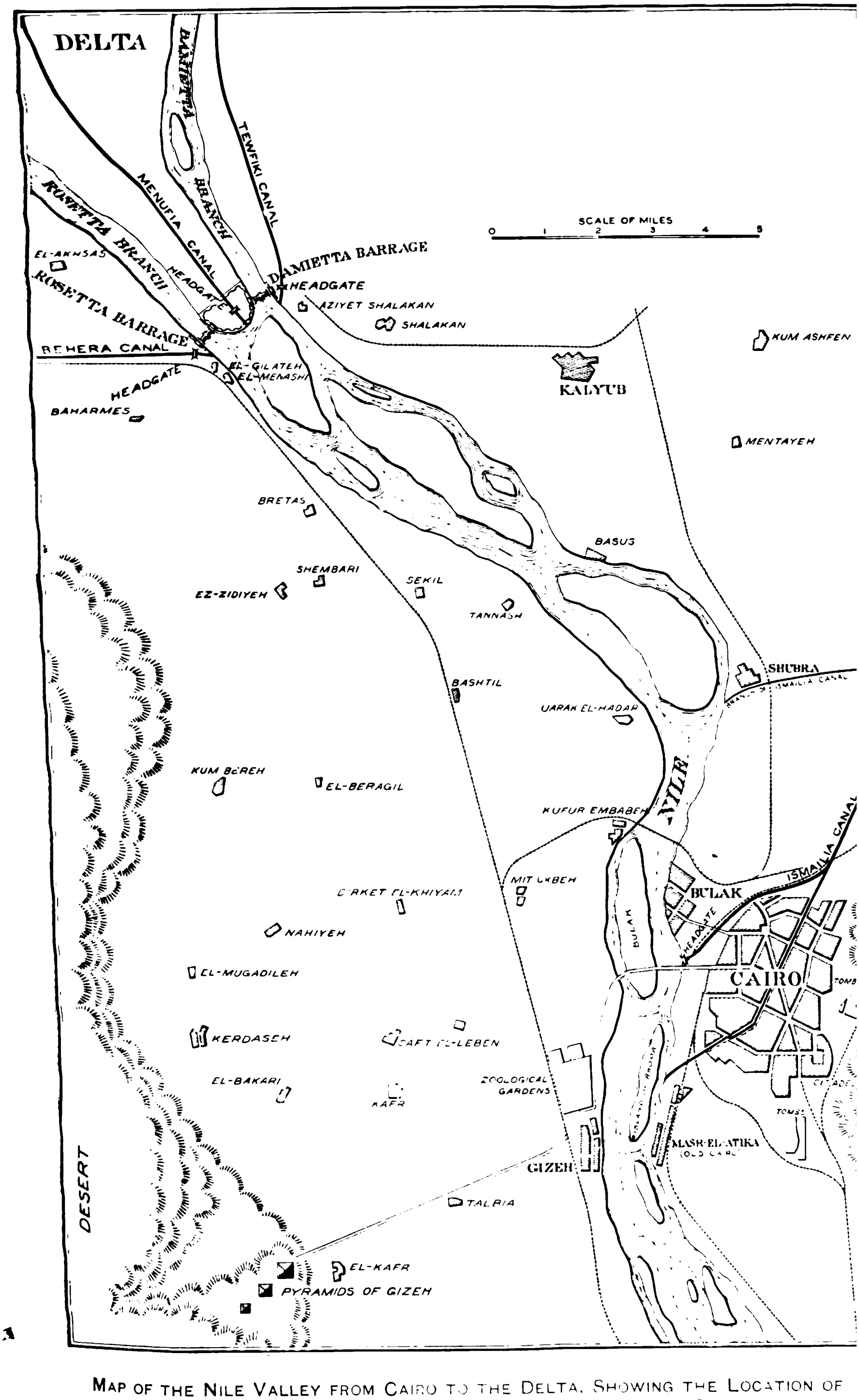
Among those on the left bank is the great Sohagia Canal, one of the oldest water channels in Egypt. It supplies 340,000 acres of land. At its lower extremity the Yusef Canal begins, being a continuation of the Sohagia. So ancient are these channels that they have lost much of their resemblance to the canals of to-day and are now considered natural channels. They are very tortuous, and run at but slightly higher levels than the Nile. At its head the Sohagia is 230 feet wide on the bottom, 278 feet wide on top, and carries a maximum of 18 feet of water in depth. Its discharge is about 15,000 cubic feet per second. The canal is separated by embankments from the first basins it supplies. In the basins farther north the canal embankments are omitted. Here the canal is not a boundary line between basins, but flows through each. The length of the canal is about 60 miles. Just below its point of diversion from the river an immense masonry head gate has been erected. It is many times too large for the volume of water carried by the canal, and it would look much more in keeping with the surroundings if the canal were two or three times larger. The head gate contains 214 archways, each of which is nearly 10 feet wide. The foundation, which rests upon sand and gravel mixed with Nile mud, is 131 feet wide and 6½ feet thick. The superstructure is of brick, except the corners and other exposed parts, which are of stone. The piers are 6½ feet thick, and are about 20 feet high from the foundation to the springing line of the archways. The discharge is regulated by raising or lowering flashboards by means of a winch carried on a car running along the top of the structure. The basins filled by the canal are emptied at an escape not far from Assiut. Until recently they were drained by simply making a cut in the basin dike, permitting the water to flow back into the Nile. This was a very dangerous and destructive practice and has been reformed by the installation of a masonry escape.

In the province of Assiut two canals divert water from the left and eight from the right bank of the river. On the left bank there are also six laterals of the Ibraimia Canal. The Yusef Canal is now supplied by the Ibraimia at the town of Dirut, 54 miles north of Assiut. The Ibraimia Canal was never supplied with a head gate until recently, when the construction of the Assiut dam made it necessary that the discharge of the canal be controlled at Assiut, where immense masonry

regulators and division gates have been put in. At Dirut there is a wasteway in the canal, through which the surplus water can flow back into the Nile. Just below the wasteway the division gates are located, and at this point the Yusef and two less important canals begin. The length of the Ibraimia Canal from Dirut to its lower terminus is about 130 miles. It flows almost parallel to the Nile, and in no place is it over 2 or 3 miles from the river. At Dirut the width of the canal on the bottom is about 65 feet, and the slopes of its banks are 2 horizontal to 1 vertical. The depth of water in the canal when full is about 30 feet. The water supplied to the Ibraimia Canal at Assiut serves to irrigate over 1,000,000 acres of land. About 600,000 acres of this is still irrigated under the ancient basin system.

The Yusef Canal supplies a number of basins along its course, but its principal duty is to furnish the Fayum province with water for perennial irrigation. The cross-section dimensions of this canal are very irregular. It averages about 175 feet in width on the bottom and has a depth of about 20 feet. There are levees on each side, however, which enable it to carry 30 feet of water at high Nile. During May and June it carries about 600 cubic feet of water per second. During high Nile the discharge is about 30,000 cubic feet per second. During low water summer cultivation is prohibited along the canal except in the Fayum province. The entrance to this province is between two desert plateaus, and the low gap is closed by a dike which completely separates the province from the Nile Valley proper. The Yusef Canal crosses this dike on a masonry structure composed of three arches. The Fayum province was formerly cultivated as the valley of the Nile had always been, but perennial irrigation is practiced at the present time, owing to the increased supply of water furnished by the canal. At the town of Medinet the canal separates into many smaller ditches, and a large part of the province is watered by these. About 250,000 acres are cultivated in the province. The slope of the land in the Fayum is greater than in any other farming district of Egypt. All the land in the province drains into Lake Kerun, which is 130 feet below the level of the Mediterranean.

In the province of Minieh three canals divert water from the right bank of the river. The three canals on the left bank are laterals of the Ibraimia Canal. These are quite important among the distributing works of the province. In the province of Benisouef six canals take water from the left and two from the right bank of the river. There is one important branch of the Ibraimia Canal in this province. In the province of Gizeh three canals take water from the left and one from the right bank of the river. Below Cairo there are many canals (Pls. X and XXIV). The principal ones are those leaving the Nile at the barrage and the Ismailia Canal, which diverts water from the river at Cairo.



MAP OF THE NILE VALLEY FROM CAIRO TO THE DELTA, SHOWING THE LOCATION OF THE BARRAGES AND THE HEAD WORKS OF THE PRINCIPAL CANALS.

The Ismailia Canal deserves special mention because it was constructed wholly by contract and in one piece. The Egyptian Government entered into an agreement with the Suez Canal Company to construct a navigable waterway from the Nile to some point on the Suez Canal. The canal was not only to be navigable, but was to be capable of furnishing fresh water to the towns along the main canal and the branch beginning at Ismailia and running parallel with the Suez Canal to the town of Suez. In addition, the canal was to supply water for the irrigation of a considerable area ceded by the government to the company. The contract stipulated that the canal should be so constructed as to contain 8 feet of water in depth during flood season of the Nile, 6½ feet at mean discharge, and 3¼ feet at low water. The canal has two head gates, the older one being in the city of Cairo. The second head gate is about 4½ miles north of Cairo, from which point a branch canal 2½ miles long connects with the main channel 5½ miles northeast of Cairo. For some distance the canal runs northeasterly along the edge of the desert, after which it turns to the east through a gap in the desert hills and continues to the town of Ismailia. For some 40 miles from Cairo it runs above the level of the surrounding country, and the water is confined between two parallel embankments. This has resulted in considerable seepage, which has destroyed large areas adjoining the canal. Some work has been done toward draining a portion of this country. Just before reaching Ismailia a branch of the canal takes off to the south and terminates at the town of Suez. In digging the canal some traces of an ancient channel leading in the same direction were discovered. Historical accounts of an older canal have been found. About 600 B. C., King Nekos began the construction of a navigation channel running between the east arm of the Nile and the Red Sea. The channel was never finished, although 120,000 natives employed upon it lost their lives in the undertaking.

The length of the Ismailia Canal from Cairo to Lake Timsah, near the town of Ismailia, is about 80 miles. The length of the branch leading south from Ismailia to Suez is about 53 miles. The bottom width of the main canal is about 40 feet. The slopes are 3 to 1. The bottom width of the branch canal leading to Suez is only about 25 feet, but the channel was not well excavated and the width is not uniform. In places it does not exceed 16 feet. Many important masonry structures are found throughout the length of the canal. Swing bridges are numerous, and substantial head gates and regulators are found wherever the discharge of the canal has to be changed. Owing to the depth to which the canal has been dug, and the necessity for keeping it cleaned out so that it will carry sufficient water for navigation during low stages of the Nile, large quantities of silt have to be removed each year. Formerly this deposit frequently amounted to 350,000 cubic yards each season. It has been reduced to about 160,000 cubic

yards by partially closing the head gates of the main canal during high water and supplying it through the smaller canal already referred to, diverting water 4½ miles north of Cairo. Considerable work is required each year at the head gate of the supply canal. It is over a quarter of a mile from the bank of the river. The channel leading to this head gate fills with back water from the river during high Nile and immense quantities of mud are deposited.

Many of the canals in the delta are ancient river channels. Those taking water from the Nile at the barrage are artificial. Among these latter is the Manufia Canal (frontispiece), which is one of the most celebrated in Egypt. It furnishes water for the irrigation of nearly all the land in the delta lying between the two branches of the Nile. The head gate of the canal is similar in design to the barrage itself. (Pl. XI, fig. 2.) A lock has been provided at the head gate, and the canal furnishes an important waterway for the internal commerce of the delta. The canal is from 160 to 175 feet wide on the bottom, and at high water carries nearly 30 feet of water in depth. Its summer discharge is nearly 4,000 cubic feet per second.

The Tewfiki Canal diverts water from the Damietta branch of the Nile at the eastern extremity of the barrage. It was begun many years ago, but was not finished until after the occupation by the English. It furnishes water for a large area lying east of the Damietta branch, and its construction has added greatly to the value of this region through the introduction of perennial irrigation. The Béhèra Canal leaves the Rosetta branch of the Nile at the western extremity of the barrage. It is about 60 feet wide on the bottom, with slopes of 2 to 1. It runs for a considerable distance along the margin of the desert, hence receives large volumes of sand which, with the silt deposited during high Nile, have to be cleaned from the channel each year. Until recently nearly 1,000,000 cubic yards had to be removed annually, and, in spite of the enormous amount of work performed, the canal carried less than 600 cubic feet of water per second. The Béhèra Canal is about 25 miles long. At its lower extremity the Katatbeh Canal begins. It has about the same dimensions as the Béhèra Canal. It supplies all the smaller canals to the north and west. The surplus water from the drainage of the land it serves flows into Lake Mareotis. The Mahmoudia Canal begins 34 miles from the barrage of the Rosetta branch of the Nile. This canal runs for about 45 miles to the northwest and ends at Alexandria. It supplies fresh water for that city besides furnishing water for irrigating a large area. The Mahmoudia Canal has for a long time been supplied with water by means of immense pumps located at Atfeh. Since the repair of the barrage the pumps of Katatbeh have been removed to Mex, which station keeps down the level of Lake Mareotis.

CONSTRUCTION AND MAINTENANCE OF CANALS AND LEVEES.

Nearly all large public works in Egypt have been constructed by the corvée (See p. 74.) The system was much abused when the English began their occupation in 1882. As soon as possible some relief was afforded the corvée by direct appropriations, under which a part of those employed on public works were paid for their labor at a price fixed by the government. These appropriations were increased until in 1889 all work of cleaning canals was paid for. Since that time the corvée has been called out only for the protection of the Nile levees during flood season, a period of from sixty to ninety days. While thousands of men are thus compelled to give their time without compensation, it is for the public benefit, and the length of their service is short, seldom longer than fifteen or twenty days. But little complaint is now heard, as the work is necessary and the service must be compulsory to be efficient. The time will doubtless come when this service will also be paid for.

The manner in which the native digs or cleans canals is interesting. His one tool, which resembles a hoe, is illustrated in the accompanying sketch (fig. 7). The engineers measure the material which is to be removed, and each man or party excavates a certain section containing a known yardage. (Pl. III). Frequently a number of men will work together, one using a hoe and the others carrying baskets holding about half a cubic foot of earth. The earth is loosened and the baskets filled by the use of the hoe. Where dry sand is encountered the hands are used to fill these baskets. Children are often seen carrying the baskets, but the hoe is nearly always handled by the men. Under this method of excavation canal sections are made smoother and more regular than under the methods commonly employed in the United States. Steps of earth are left in the banks, enabling those carrying material to walk with considerable ease. On the smaller canals and laterals the earth is often loosened with the hoe and thrown out by hand. Sometimes it is necessary to clean these when a foot or more of water is standing in them, in which case the material, if plastic, can be easily handled. Where the banks are higher, the earth may be thrown by a man in the bottom of the ditch to another on the bank, and by him pitched out.

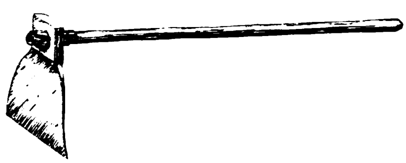


Fig. 7.—Hoe used by native farmer.

Near Medinet el Fayum a photograph was secured of a number of natives cleaning a small ditch. (Pl. IX, fig. 2.) The soil was a black loam, thoroughly saturated with water. The men loosened the material with their hoes where necessary and removed it by hand. The material was sufficiently plastic so that each handful retained its form

after being deposited. After a day or so in the sun these become dry and hard and are of no value in the bank of the ditch. On an average one man can excavate about 3 cubic yards of earth a day if the lift be not too great. For this service he is paid about 15 cents, which admits of the cleaning of a canal at the rate of 5 cents per cubic yard. This is the cheapest method of performing the work under Egyptian conditions. It costs about 15 cents per cubic yard to clean a canal with a steam dredge, owing to the higher price of labor necessary to run the machine and to the cost of coal. The large canals are usually cleaned after the water has been drained out and they have dried. When it is impossible to drain them completely the unpleasant features of the work are greatly increased.

WATER-RAISING DEVICES.

As has been before stated, most of the water for irrigation, except in that portion of Egypt which still retains the ancient basin system, flows below the level of the land to be irrigated, the necessary lift varying with the stage of the river. The native machinery for lifting water has been designed to work regardless of this fluctuation. While none of this machinery is efficient, it serves for the irrigation of a large area. The shaduf and the sakiyeh are used when the fluctuation is great or where the lift is over 5 or 6 feet. Both are of ancient origin. They can be applied to almost any lift, are easy to construct, and do not require many repairs.

But little is known regarding the lifting machines used by the ancient Egyptians. Probably the first devices invented by them were much more primitive and not as efficient as those used to-day. Many of these machines have become obsolete because it was found that they did not have as wide a range of application as have the devices now generally employed. It may be that the scarcity of the material from which the lifting devices were built has largely affected the change in design.

THE SHADUF.

The shaduf consists essentially of two vertical supports about 5 feet apart connected by a horizontal crosspiece some 5 feet from the ground, a pole hung on this crosspiece like a well sweep, and a bucket suspended from this pole. In many places the uprights supporting the crosspiece are made of small sheaves of cornstalks stiffened with a coat of Nile mud. Sometimes the mud is used alone. The pole is hung 6 inches beneath this crosspiece, as shown in Pl. XII. This pole is not balanced, but is supplied with a counterweight on the shorter end, which extends away from the water. Suspended from the other end is a long pole to which a bucket is attached. This bucket is usually made of leather stiffened near the top by a wooden hoop. Its capacity

FIG. 1.—LATERAL HEAD GATE.

FIG. 2.—HEAD GATE OF MANUFIA CANAL.

THE SHADUF.

is approximately 2½ gallons, or one-third of a cubic foot. The counterweight is generally a piece of sun-dried Nile mud held together with straw, cornstalks, or sugar-cane leaves. The woodwork is generally rough and the whole structure shows a lack of neatness. The operator throws his weight on the sweep, the bucket fills, and the counterweight raises it to the channel into which it is to be poured. The ground where the water falls is protected from erosion by a matting of vegetable fiber. A single shaduf can lift water only 5 or 6 feet, but it is the custom to install them in series of three or four, which work together, raising the water from 20 to 30 feet. A number of shadufs so operated need not necessarily be in a line. It is quite common to find the lower shaduf 50 or even 100 feet up or down stream from the others, but it is better to get them as close together as possible, to reduce the loss by seepage.

A shaduf operated by one person can raise about 3 cubic feet of water per minute. A man usually works two hours at a time, and two men relieving each other put in about ten hours a day. They can, therefore, with one machine, raise 1,800 cubic feet of water per day. Assuming that at each irrigation the land is covered to a depth of 1 inch, a device of this kind would irrigate about half an acre a day. The following table shows the efficiency of a number of shadufs on which data were obtained:

Efficiency of the shaduf as a water-raising device.

Height of lift.	Number of shadufs in series.	Cost of running machines per day of ten hours.	Area irrigated in ten hours.	Cost per acre each irrigation.	Discharge per day.	Area of field irrigated.	Cost per acre for each foot of lift.
			Acre.		*Acre foot.*	*Acres.*	
2.8 feet	1	$0.30	0.21	$1.43	0.06	0.98	$0.51
3.3 feet	1	.32	[illegible]	1.88	.06	1.21	.57
3.3 feet	1	.30	.19	1.58	.07	1.18	.48
3.9 feet	1	.30	.19	1.58	.05	1.10	.41
4.2 feet	1	.29	.15	1.93	.05	.91	.46
5.7 feet	1	[illegible]	.18	[illegible]	.04	1.15	[illegible]
5.8 feet	1	.30	.12	2.50	.04	[illegible]	[illegible]
9.1 feet	1	.35	.12	2.92	[illegible]	1.00	[illegible]
10.4 feet	2	.60	.10	6.00	[illegible]	[illegible]	[illegible]
15.8 feet	2	.65	.10	[illegible]	[illegible]	[illegible]	[illegible]
19.3 feet	2	.60	[illegible]	6.67	[illegible]	[illegible]	[illegible]
19.4 feet	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.5 feet	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22 feet	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29 feet	4	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
29 feet	4	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]

THE SAKIYEH.

The sakiyeh is as common as the shaduf. It is estimated that there are 12,000 of them in that part of the delta between the branches of the Nile. There are probably 50,000 altogether in Egypt. The machine is constructed as follows: A horizontal wooden wheel, about 10 feet in diameter, furnished with cogs projecting [illegible] from its circumference, is supported on a vertical shaft, [illegible]

which is pointed and rests on a wooden bearing. The upper end of this shaft is generally of small diameter and is thrust through a hole in a horizontal beam 22 or 23 feet long and supported at its ends by columns of sun-dried bricks or masonry. Sometimes wooden posts or even two small pieces of wood crossed and tied together are substituted for these columns. Projecting radially from the horizontal wheel is an arm to which is hitched the animal furnishing the power. The teeth on the horizontal wheel engage similar teeth on a vertical wheel, the shaft of which passes underground to a second vertical wheel over the water to be lifted. The details of this wheel and the earthen jars it carries are shown in the accompanying illustration (Pl. XIII, fig. 1). Where the lift exceeds half the diameter of the wheel the jars are attached to a belt which passes around a small wheel in the water or simply hangs by its own weight. Sometimes the sakiyeh is built on a masonry foundation. The shaft of the horizontal wheel then has a stone bearing and the beam supporting the shaft rests on the masonry walls. While the wooden parts have to be replaced quite often, the masonry work is practically permanent.

An ox or a buffalo is usually employed to work the machine. Each animal is relieved every three hours and generally works two periods per day. Sometimes two animals are driven together. This is common when a double belt, furnished with jars quite close together, is used, or where the lift is very high. In the Fayum the sakiyehs are often turned by the current of the canals. In the delta the vertical wheel carrying the jars is frequently replaced by one having small compartments built in its circumference. The jars ordinarily used on a sakiyeh weigh about 2½ pounds each and hold about half a gallon. A sakiyeh will raise from 120 to 180 cubic feet of water per hour, depending upon the height of the lift. The efficiency of the device is reduced by its lifting the water higher than necessary by about a third of the diameter of the wheel. It has been estimated that one sakiyeh will do the work of four shadufs. This is approximate and is doubtless too high.

A number of improvements have been made in these machines recently and they are now manufactured by British firms and imported into Egypt. Being constructed of iron, the first cost is often prohibitive, repairs are difficult, and it is not easy to install them where the sites have been designed for larger sakiyehs.

The cost of operating a sakiyeh, using one animal at a time, is about $1.50 per acre each irrigation, for lifts not exceeding 12 feet. From 12 to 18 feet the cost will probably reach $2.40 per acre, and from 20 to 30 feet, $3.60 per acre. If the animals used are owned by the irrigator, the cost will be considerably reduced. The sakiyeh itself may cost all the way from $10 to $150, depending upon the location, the cost of the material of which it is constructed, the price of labor, and whether or not masonry is used in the walls and foundation. The following table has been prepared from notes taken in the field:

Efficiency of the sakiyeh as a water-raising device.

Height of lift.	Number of animals working two or two and a half hour periods.	Cost of running machines per day of ten hours.	Area irrigated in ten hours.	Cost per acre each irrigation.	Discharge per day.	Area of field irrigated.	Cost per acre for each foot of lift.
			Acre.		*Acre-foot.*	*Acres.*	
3 feet	2	$0.60	0.74	$0.80	0.24	10.3	$0.27
5 feet	2	.60	.66	.90	.23	8.6	.18
5.50 feet	2	.63	.66	.95	.24	8	.17
6 feet	2	.58	.78	.74	.21	9.4	.12
7.75 feet	2	.51	.65	.80	.21	7.3	.10
8.75 feet	2	.69	.65	1.06	.20	7.6	.12
10 feet	2	.60	.64	.94	.23	7	.09
12.50 feet	2	.57	.57	1.00	.26	6.1	.08
16 feet	2	.49	.66	.74	.20	7.2	.05
19 feet	3	.82	.47	1.74	.17	5.3	.09
5 feet	4	1.05	.49	2.14	.16	4.8	.09

THE ARCHIMEDEAN SCREW.

In the delta a number of unusual methods are employed for raising water from 1 to 4 or 5 feet. One of the most striking of these, and one the least to be expected in Egypt, is the Archimedean screw. Around an iron shaft some 14 or 15 feet long is built a screw, made up of thin pieces of wood so fitted together as to be practically water-tight. A water-tight wooden cylinder is constructed around the screw. The diameter of the cylinder is ordinarily about 14 inches, and its length does not often exceed 8 or 9 feet. The pitch of the screw is about 1 revolution to 1½ diameters. The screw is so attached that it will not revolve on the shaft. The shaft projects from both ends of the cylinder and is supported near its extremities by posts. The screw inclines 30 degrees or less to the horizon, with its lower end in the water. To the upper end of the shaft a crank is attached. This lifting device is shown in the accompanying illustration. (Pl. XIV.) One or two men usually operate a screw, but in rare cases, when the screw is especially large or the lift considerable, a small engine is employed. High lifts are practically impossible on account of the difficulty of supporting a screw of great length. This device is more efficient than the lifting machines contrived by the natives. One man can irrigate from 1 to 2 acres a day with this machine, provided the lift be not over 2 feet. The efficiency of the Archimedean screw is shown in the following table:

Efficiency of the Archimedean screw as a water-raising device.

Height of lift.	Number of men working periods of two hours.	Cost of operation per day of ten hours	Area irrigated in ten hours.	Cost per acre each irrigation.	Discharge per day.	Area of field irrigated.	Cost per acre for each foot of lift.
			Acres.		*Acre-foot.*	*Acres.*	
3.3 feet	2	$0.31	1.22	$0.25	0.47	14.2	$0.08
4.5 feet	2	.27	1.12	.24	.49	10.8	.05
4.6 feet	2	.27	1.36	.20	.52	10	.04
5.1 feet	2	.29	1.02	.28	.45	6.4	.06
5.9 feet	2	.30	1.14	.26	.41	11.7	.04

THE NATALI.

In the delta a great deal of water is raised by means of another curious device, known as a natali. Two men operate a bucket to which is attached four cords. These cords are held by the men and the bucket is alternately filled and emptied with remarkable dexterity. Pl. XV shows this device in use. But little preliminary construction is needed before the work of raising water can be commenced. A channel is generally dug from the water into the bank of the canal and platforms are made for the men to stand on. Where the water is poured into the ditch leading to the fields the bank is protected, as in the case of shadufs, by a matting of vegetable fiber. Two men can raise about 100 cubic feet of water per hour to a height of 3 or 4 feet. The accompanying table gives some information relative to the efficiency of this contrivance:

Efficiency of the natali as a water-raising device.

Height of lift.	Number of men working periods of two hours.	Cost of operation per day of ten hours.	Area irrigated in ten hours.	Cost per acre each irrigation.	Discharge per day.	Area of field irrigated.	Cost per acre for each foot of lift.
			Acre.		*Acre-foot.*	*Acres.*	
0.7 foot	2	$0.28	0.94	$0.30	0.27	6	$0.43
0.8 foot	2	.30	.98	.31	.26	6	.39
1.0 foot	2	.28	.88	.32	.26	7.2	.32
1.5 feet	2	.30	.66	.45	.21	6.6	.30
1.6 feet	2	.30	.51	.60	.21	5.1	.38
1.9 feet	3	.46	.78	.60	.24	5.4	.32
2.1 feet	2	.31	.65	.48	.20	6.3	.23
2.3 feet	4	.58	.64	.90	.22	5.1	.40
2.7 feet	4	.65	.71	.91	.20	5	.34
2.8 feet	4	.54	.70	.77	.20	4.6	.27

PUMPING.

Small pumping plants are becoming common and some expensive and well-equipped pumping stations have been erected in various parts of Egypt. The design most commonly met with is an 8-inch centrifugal pump propelled by an 8-horsepower steam engine. Coal is usually burned in these engines, although cornstalks and straw are substituted for it in Upper Egypt. Coal costs $7 per ton at Alexandria, the price increasing with the distance from that port.

As early as 1882 there were 2,645 pumps and engines lifting water from the Nile and from canals. The engines had a total horsepower of 29,453. Of the plants 2,226 were movable and 419 were stationary. The stationary engines had a total horsepower of 9,382, while the movable engines had a horsepower of 20,071. Nearly all of these pumping plants were located in the delta, although there were a number between Cairo and Assiut. Above that there were no movable plants and only 17 stationary engines and pumps. The number has not increased appreciably since that time, but modern pumps have,

FIG. 1.—SAKIYEHS.

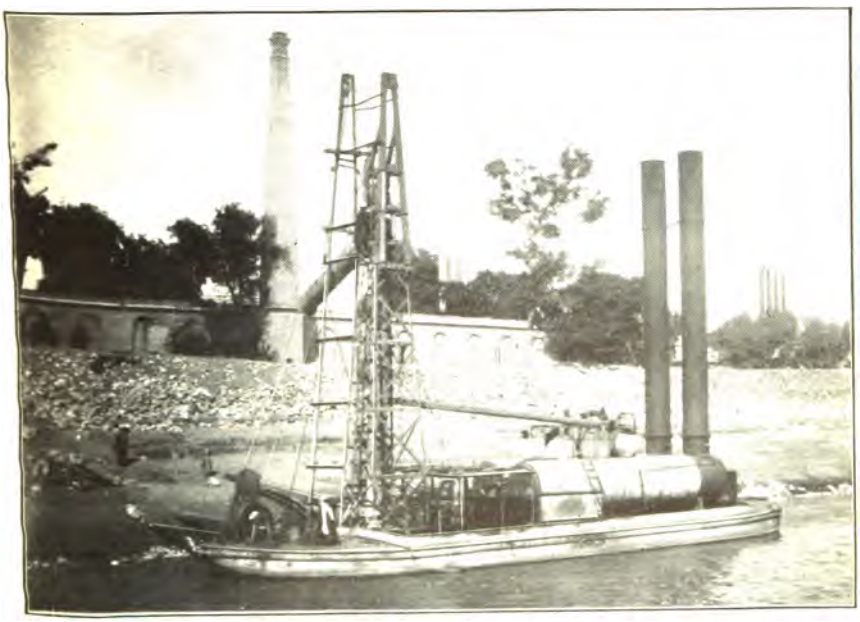
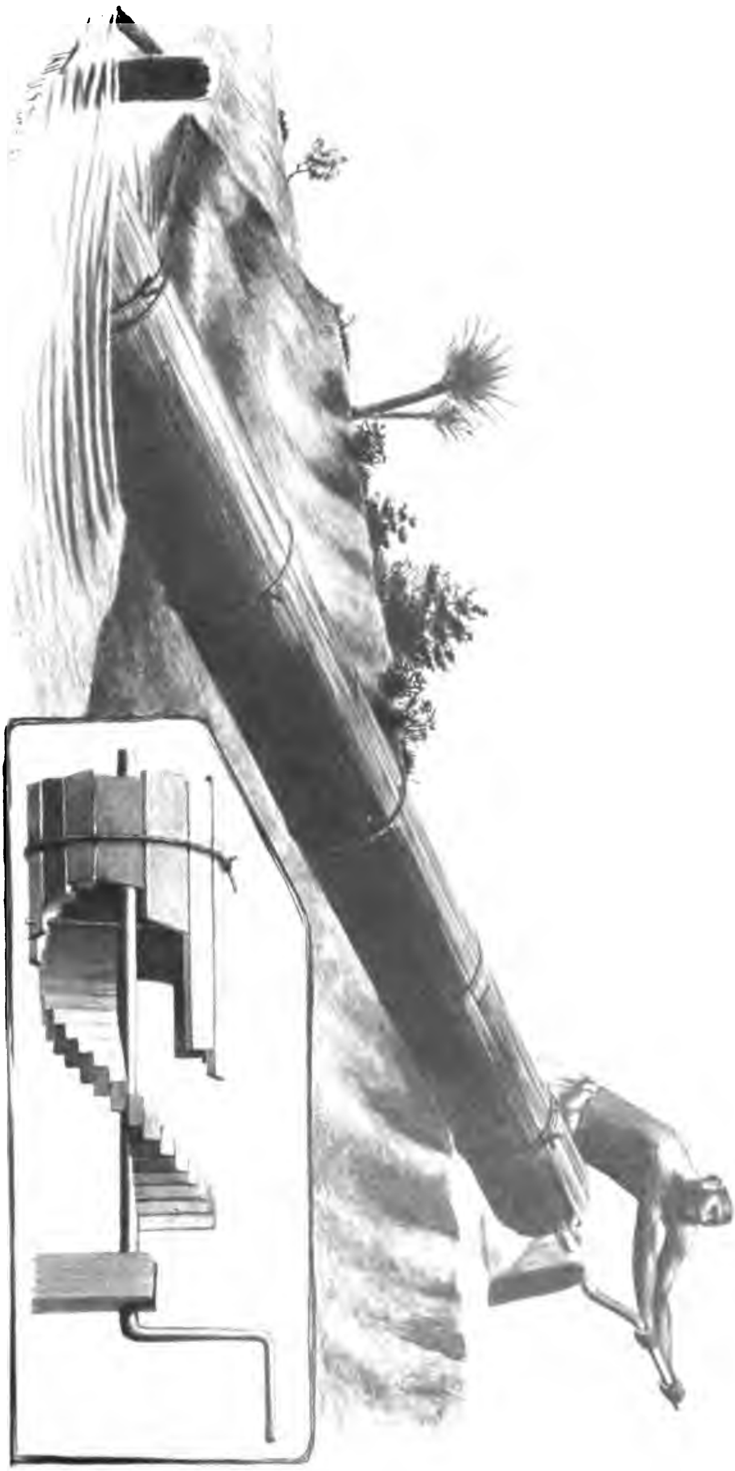


FIG. 2.—A STEAM PUMP ON A SCOW.



ARCHIMEDEAN SCREW, SHOWING INTERIOR CONSTRUCTION AT RIGHT.

THE NATALI.

in many cases, been substituted for those originally employed. Pumping plants are frequently seen on scows on the river. (Pl. XIII, fig. 2.) These go from place to place and furnish water under contract. Where the lift is not over 8 or 10 feet and where the owner of the field is a part owner in the plant, steam pumps furnish water at about $1.90 per acre for each irrigation. If the farmer is not interested in the plant the cost per acre may run as high as $3.75 or $4 for each irrigation. Cotton has to be watered four or five times during the growing season. Wheat, maize, and all fodder crops are generally twice irrigated. Figures quoted by engineers as to the cost of pumping water vary greatly. The outlay for this service depends largely upon the local practice of the irrigator. Mr. Thorwald L. Smith, agriculturist of the Société du Béhèra, which controls a considerable area in the delta, has furnished the following information regarding the character of the pumps employed by the society, together with their discharge, the quantity and cost of coal consumed, etc. The pumps employed are either of English or French manufacture, and are not superior in any way to those made in the United States. A detailed description of them is therefore unnecessary.

Efficiency of pumping plants owned by the Société du Béhèra, Alexandria.[a]

Description of centrifugal pump and engine.	Discharge per second.	Expense of operation per day of ten hours.				Total cost per day.	
		Coal.[b]		Lubricants and sundries.	Engineer and fireman.	Ten hours.	Twelve hours.
		Pounds.	Cost.				
	Cubic feet.						
20-inch direct-acting compound condensing Gwynne pump	17.66	1,212	$5.45	$0.18	$1.23	$6.83	$8.13
20-inch Ruston and Proctor, driven by belt from semiportable compound condensing engine by same makers	17.66	1,212	5.45	.18	1.23	6.83	8.13
18-inch Dumont pump, driven by belt from a Ruston-Proctor compound condensing portable	17.66	1,212	5.45	.18	1.23	6.83	8.13
16-inch Ruston-Proctor pump, driven by belt from compound condensing portable by same makers	10.60	772	3.47	.18	1.23	4.86	5.83
12-inch Gwynne pump, driven by belt from single cylinder non-condensing portable	6.70	662	2.98	.18	1.23	4.86	5.83

[a] Tests running from 1895–1901; lift, 6.5 feet.

[b] Coal at $8.94 per ton.

DUTY OF WATER.

Some tests have been made in both Upper and Lower Egypt to determine the duty of water. The lack of careful measurements of the water supplied for irrigation discredits many reports which would otherwise be valuable. The rated capacity of the pumps is too often used in computing the volume of water furnished. When gaugings are made to check the pumps, it is generally found that the discharge has been overestimated. The water is usually measured on the border

of the field, so that but little loss occurs between the pump and the irrigated land. In lower Egypt it has been found that a depth of water of 2.55 feet is sufficient for the irrigation of cotton. A depth of 4.3 feet is required for rice. The winter crops, which have already been enumerated, demand from 1.6 to 2 feet. Although the growing season of sugar cane, the most valuable crop in upper Egypt, covers a period of nine months, a depth of water of 2.5 feet suffices for its needs.

The following discussion of the duty of water under some of the pumping plants of the Société du Béhèra, in Lower Egypt, has been furnished by Mr. Thorwald L. Smith:

* * * The loss through evaporation and absorption varies greatly according to the following conditions:

(1) Quality of soil: (a) Sandy; (b) medium; (c) heavy.

(2) Time of year: (a) Hot; (b) cold.

(3) Number of days elapsed since last watering.

(4) Distance of field from pump: (a) Water carried in old permanent channel; (b) carried in temporary channel for that particular crop.

As to the first, we find that in (a) sandy soil (pure alluvial deposits) the quantity of water required for each watering is about double that wanted for heavy (c). On the other hand, such soil cracks less, and, consequently, there is not so much loss, should the time between two waterings be prolonged, as there is in heavy soil where, after a long drought in summer, the cracks (unless the land be frequently hoed) will continue to absorb all the water for some minutes and will conduct it to the subsoil, which is salt, where it can be of little use to the surface-feeding crops.

Second. Time of year makes a difference in two ways: First, because in summer a lot of water is lost by evaporation so soon as it is spread in a thin layer over the baked land, and second, because in the cooler months the canals are all generally running full and consequently all low lands can be irrigated by gravitation and are more or less water-logged, especially where drainage is bad. In fact, for winter crops the only time when pumps are used for such lands is when the upper reaches of the canals have been closed for clearance and the water in the lower reaches falls below the ground level.

Third. The number of days between each watering for cotton should be an average of fifteen, but through want of water this is frequently prolonged to thirty or even more. Naturally from causes mentioned above, i. e., cracking, and from the fact that evaporation directly and through the plants has been going on continually, the land takes more water to show any sign on the surface. For the rice crop these last conditions can not obtain, for water must be changed in rice fields while the crop is young at least every four days, and when stronger at a maximum of eight days on good soil. (Where the land is very salt the crop would suffer very much, if not die, in an eight-day interval.) On the other hand, as the rice land is continually wet the absorption at the time of watering is much less, and of course there are no cracks. However, as the water is on the surface there is great evaporation from sun and wind, especially so long as the plant is small and does not shade its own roots.

In calculating (theoretically) the amount of water necessary for each watering, about 3.94 inches in depth would appear to be sufficient. Indeed, in the case of cotton which is sown on ridges, one might think that the area of the furrows only, into which the water runs, i. e., about half the total area, would be the figure on which to base the quantity necessary. But the ridges, being made up entirely of loose soil, soak up water at once, especially the first watering or after a hoeing, and

carry almost as much as a furrow. I may say at once that the 3.94 inches over the whole area for cotton, even when the ground is not much cracked, is quite insufficient, and in a long furrow that quantity would not reach the end. Of course, to equalize the supply to each plant the field is divided longitudinally into narrow belts and these belts crossways into short beds. This division is made after the field has been prepared and ridged up, the original ridges stretching from one end of the field to the other. Between each belt is a small water channel, which is what I refer to in 4 (b). In these channels a good deal of water must be wasted. As to the permanent waterways we calculate a mean loss of 10 per cent for absorption and evaporation. * * *

THE CAIRO BARRAGE.

In 1798 and 1799, during the French occupation, Napoleon called attention to the advisability of constructing dams across the Rosetta and Damietta branches of the Nile. Perennial irrigation had probably not occurred to him, but he saw the advantage of being able to turn the whole discharge of the river down one branch or the other so that the lands along either might receive the benefit of the entire flow. The dam would probably not have been built had this been its only function, but his suggestion may have led Mohammed Ali to introduce perennial irrigation in Lower Egypt.

In 1833 Mohammed Ali favored building a stone dam across the Rosetta Branch so that it might be entirely closed. This would raise the level of the water considerably at the site of the dam and afford a better supply to the canals taking water from the Damietta Branch, along which was the larger irrigated area. Before work was begun he was persuaded to change his plans. It was suggested to him that in place of building a dam across the Rosetta Branch one be erected on each branch 6 miles below their point of divergence. The khedive approved this plan and ordered that the stone be taken from the Pyramids. All protests against this latter scheme were without avail until Linant Pasha, a government engineer, showed that, as the Pyramids were built from the bottom to the top, they would have to be dismantled from top to bottom, and that the stone thus procured would be more expensive than if taken from new quarries opened near Cairo. Everything seemed now to promise speedy completion of the dam. Workshops were erected and some material for construction had been delivered on the ground, when Mohammed Ali again changed his mind and stopped the work. Nothing more was heard of the barrage project until 1842, when Mougel Bey, a French engineer, was called to Egypt and his plans, as altered by the khedive so as to include the fortifications, led to the construction of the barrage as it stands to-day. The dam was finally completed in 1861 at a cost of $9,000,000, not counting the services of the corvée. The additional cost of fortifications, canal head gates, and incidentals made the total outlay about $19,000,000.

After this vast expenditure the dam was of no value except as a

highway across the Nile. Only the Rosetta Branch of the barrage was supplied with gates. The additional head produced by closing these caused enough pressure to crack the masonry of the dam. At the same time water ran under the structure and a number of springs appeared below. During the reign of Ismail Pasha nothing was done toward repairing the barrage. Suggestions that it might be put in condition to hold back water for the irrigation of lower Egypt were never considered seriously.

The barrage is shown in the accompanying illustrations (Pls. XVI and XVII). The Rosetta dam has 61 archways, while the Damietta Branch has 71. The height of the archways is 41.82 feet from the floor of the structure to the crown of the arch, or 32.8 feet to the spring line of the arches. The archways are 16.4 feet wide, and the piers supporting them are 6.56 feet thick. The original foundation of the dam was simply a layer of concrete 111 feet wide and nearly 9 feet thick, covered by a stone and brick floor 1.64 feet thick. As work on each section was undertaken, sheet piling was driven to keep the water quiet while the concrete was being laid. The piers were constructed on this floor. Locks were built at both ends of each dam and at the head gates of the three canals. The flow of water through the sluiceways was to have been regulated by gates of a new design, but they never proved satisfactory, although a few still remained in the dam until 1890. The gates now used close tightly, but a grating, through which the water flows at all times, is beneath the sills on which the gates rest.

Since the English have been in control of Egypt repairs to the barrage have been going on almost constantly. A new floor was laid, widening the foundation 30 feet on the downstream and 78 feet on the upstream side. It was thought better to widen rather than deepen the foundation, because the material did not improve with depth. After this work was completed new gates were put in the dam throughout. These were made of wrought iron and provided with rollers, and they slide in cast-iron grooves made fast to the piers. The gates are lifted by a traveling winch. One rail for supporting the car carrying the lifting device was put on the upstream parapet of the dam. Brick towers were built on the piers to support the second rail. These towers, with the gates now employed, are shown in Pl. XVII.

Until 1896 the springs on the downstream side of the dam continued to flow. Some water came through the gratings, but a large volume flowed under the piers. In 1896 repairs were begun which will doubtless make the barrage an enduring structure. Through holes 5 inches in diameter, drilled from top to bottom of the piers and lined with iron pipes, clay or cement mortar was rammed. It was found in this work that large cavities existed under the foundation, and as much as 40 barrels of cement were used for a single pier. The total cost of

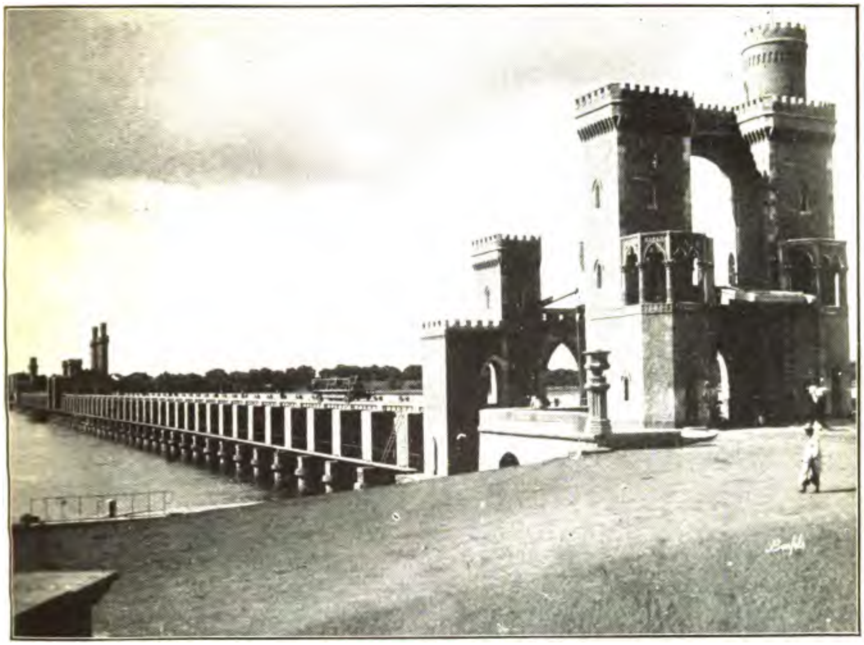
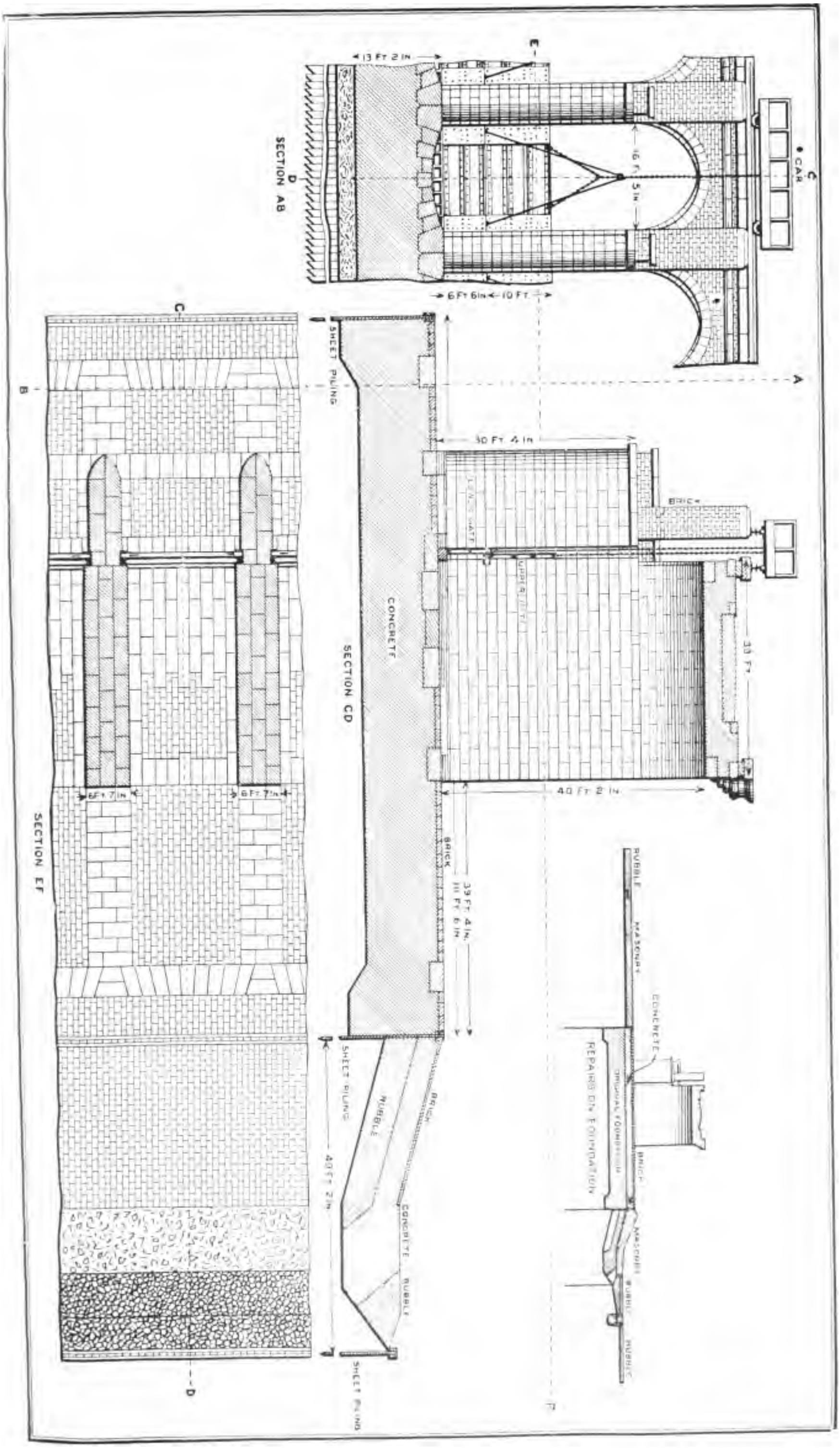


FIG. 1.—THE DAMIETTA BARRAGE FROM EASTERN BANK OF THE NILE.

FIG. 2.—ROSETTA BARRAGE FROM WESTERN BANK OF THE NILE.



DETAILS OF THE CAIRO BARRAGE.

these repairs amounted to $300,000. Another safeguard has been added to the barrage. Across each branch of the Nile below the barrage low dams have been built, raising the surface of the water there and correspondingly reducing the pressure to which the larger works are subjected.

The Egyptian Government had many times prior to 1882 discussed the matter of repairing the barrage. At one time a scheme was on foot whereby it was thought that an expenditure of $6,200,000 would make the structure serviceable. Luckily, the Arabic custom of not making repairs prevailed in this instance. Another scheme which received the attention of the government was to pump water into the canals instead of relying on the barrage at all. This would have necessitated an expenditure of nearly $3,500,000 for the establishment of the pumping plant, and an annual outlay of about $1,250,000 to keep it in operation. The government actually made a contract with a company to pump water into one of the canals during low water, and bound itself to pay at least $128,000 a year for this service. So successful, however, were the engineers in repairing the dam that by 1892 the canals heading there were fully supplied. The barrage furnishes water at a much less cost than a pumping plant, and, as the flow is regulated during the season of high water as well as at other times, a great reduction is made in the volume of silt which has to be removed from the canals each year. However, until after the occupation of the English, labor had but little value, and this item was probably not taken into consideration.

As early as 1884 the barrage performed some beneficial service for the irrigators of the delta. The alterations which first put the dam in working order cost about $2,250,000. One hundred and fifty thousand dollars are required each year for maintenance and operation. While the repairs were being carried on, the Tewfiki Canal, taken out at the eastern end of the Damietta branch of the barrage, was completed. Many auxiliary canals and ditches were dug and considerable reform was brought about in the drainage system throughout the delta.

RESERVOIRS.

The construction of reservoirs is a new departure on the part of the Egyptian Government. Storing water at Assuan during the winter for the benefit of the irrigator during the months of scarcity will necessitate changes in the irrigation systems now existing if the supply thus made available is to be distributed to the best advantage. The water supply afforded by the Nile is such that storage works can be extended almost indefinitely, or until all of the arable land of Egypt is served by perennial irrigation.

The total area of Egypt proper, embracing the great Lybian Desert,

which contains five oases and a large part of the Sinai Peninsula, is about 3[illegible] square miles. Of this less than 3 per cent, or about 6,000,000 acres, can ever be cultivated. The accompanying map (Pl. XVIII) enables a comparison to be made of the Nile Valley with that of the Platte River. It will be noticed that the mouths of the Platte and the Damietta branch of the Nile are coincident. The two rivers cross the north boundary of Colorado near the same point, and Denver and Assuan lie only a few miles apart. Egypt proper, therefore, has about the same length as the Platte Valley from Denver to the Missouri River. The width of the Platte Valley in Nebraska is about the same as that of the Nile from Assuan to Cairo. Only 5,145,000 acres are now cultivated in the valley of the Nile. A similar area of agricultural land in Nebraska would have produced in 1900 crops having a total value of about $26,000,000. The farming lands of Egypt pay more than this in taxes each year. Nebraska received in 1900 a little over $6,000,000 from all its sources of revenue. Egypt received about $60,000,000. Nebraska has no bonded indebtedness and but a small floating debt. Egypt has a complication of financial troubles, owing in the aggregate $516,000,000, or $100 for each acre of agricultural land.

But little arable land in Upper Egypt remains unreclaimed, and the area enjoying perennial irrigation can not be extended until reservoirs are provided to store the water which is needed in May and June. With the growth of the reservoir system basin irrigation will disappear. There are now 120 of these basins in Upper Egypt, varying in size from 500 to 35,000 acres. Each year many of these basins fail to receive the volume of water needed and the yield of the crops is correspondingly reduced. Taxes on such land have to be remitted, entailing a loss to the treasury of $220,000 annually. Although the basin system has been greatly improved during the past twenty years, yet so evident are the advantages of perennial irrigation that the demand for reservoirs has been growing. In Lower Egypt 1,300,000 acres can be reclaimed when water for irrigation is made available. According to a rough determination of the duty of water, made by engineers, it will require 38,000 cubic feet per second, or 75,400 acre-feet per day, to irrigate this land.

The mean discharge of the Nile for January is about 140,000 acre-feet per day. For February it is about 104,000, and for March it is 73,000 acre-feet per day, in this month falling below the volume which will be needed when all the irrigable land in Egypt is brought under cultivation. In April and June the mean discharge per day is about 51,000 acre-feet. In May it falls as low as 44,500 acre-feet per day. The mean discharge in acre-feet per day for July is 182,000. While some shortage may occur very early in this month, yet it is not one of

the critical months. During the remainder of the year the river always furnishes more water than is needed.

Mean discharge of the Nile, 1873–1892.

Month.	Acre-feet.	Month.	Acre-feet.
January	4,192,650	August	17,684,568
February	3,115,728	September	20,620,106
March	2,210,858	October	19,650,906
April	1,538,460	November	9,329,700
May	1,335,114	December	5,899,014
June	1,538,460		
July	5,484,600	Total	92,601,224

The reservoir system would, during average years, have to supply 126,000 acre-feet in March, 799,000 acre-feet in April, 1,002,000 acre-feet in May, 799,000 acre-feet in June, and probably 120,000 acre-feet during the first few days of July. The reservoirs would have to store a total volume of 2,852,000 acre-feet in order to furnish water for the irrigation of this land. Even in low-water years the Nile supplies plenty of water to fill a reservoir system of much larger capacity. If the reservoir system could be made large enough to maintain a uniform flow in the river throughout the year, it would at all times discharge about 257,230 acre-feet per day, or about 130,000 cubic feet per second. The Nile furnishes an average volume of 92,600,000 acre-feet annually. Disregarding losses in storage and transit, it is estimated that 27,521,000 acre-feet of water would irrigate all of the agricultural land. Under this assumption the land would be covered to a depth of 4.27 feet. This would leave 65,200,000 acre-feet of water unused when Egypt was fully supplied. It will be seen that the building of the Assuan reservoir, with an estimated capacity of 863,400 acre-feet, is only the first step in the construction of storage works. The Wady Ryan site alone could probably store about 3,000,000 acre-feet, enough water to supply Egypt, but it could be used only in Lower Egypt; but the natural flow of the Nile furnishes more water than is needed for Upper Egypt. If this site were improved, the Assuan reservoir would not be needed; hence, it will very likely be the policy of the government to build a number of storage works similar to the Assuan reservoir farther up the river. That the expense of maintaining these and the difficulty of controlling the discharge of water from them will be much greater than for one large reservoir, can not be doubted.

If reservoirs are constructed farther up the Nile, they must be farther from Egyptian territory, and consequently more difficult to control. Much discussion has occurred as to the feasibility of utilizing lakes Victoria and Albert in central Africa as reservoirs. But little has been done toward making surveys in that locality and no figures are available as to the cost of converting the lakes into storage works.

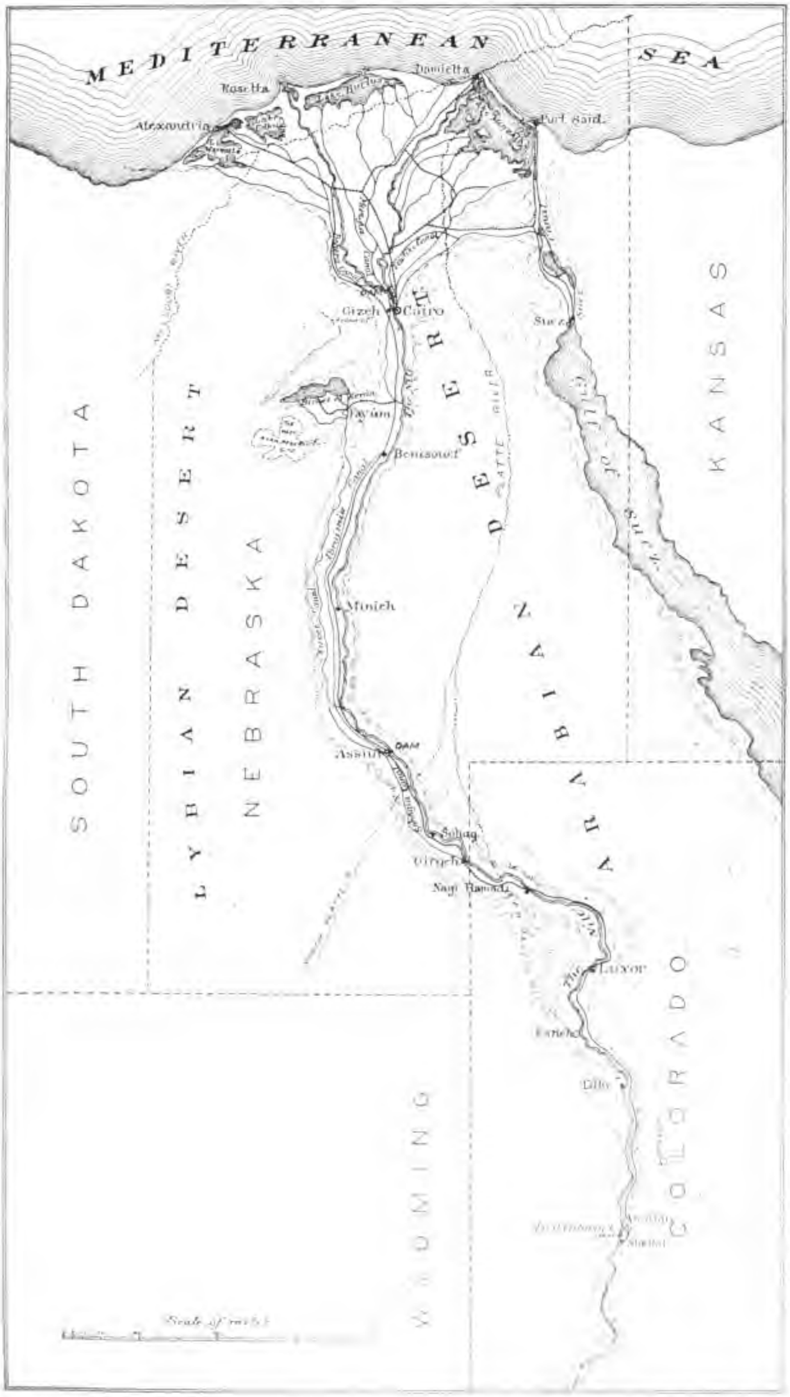
THE ASSUAN RESERVOIR.

The engineers of the Egyptian Government have realized for a long time that it would be necessary to store some of the Nile water before Upper Egypt could receive the benefits of perennial irrigation or a large area of Lower Egypt be reclaimed. For ten years before work was undertaken toward building the reservoir preliminary surveys were made and many reservoir sites were discussed. Investigators resorted to ancient history and brought forth all the known facts regarding Lake Moeris, which occupied part of the basin now known as the Fayum province. One American engineer, who had studied this subject and made some surveys, held that the Wady Ryan was formerly Lake Moeris. Whether or not this be true does not matter at this time. To-day it is the only practicable reservoir site between the Mediterranean and Assuan. (See Pl. XIX.)

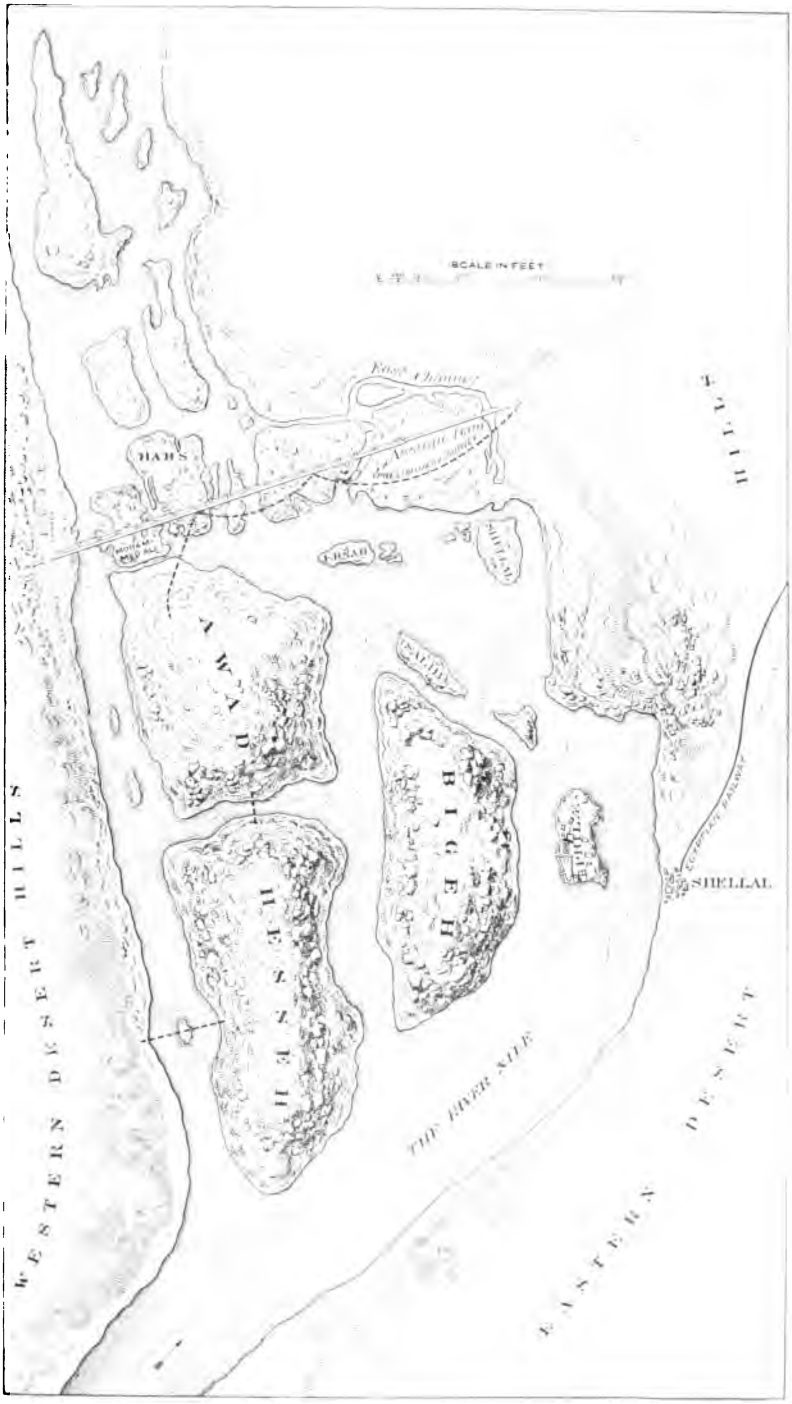
Early in 1894, after considerable discussion as to how reservoir construction should be carried on and what sites should be utilized, a technical commission was appointed. This commission consisted of Sir Benjamin Baker, an Englishman; Auguste Boulé, a Frenchman, and Giacomo Torricelli, an Italian. They left Cairo February 26, and returned March 23, having examined all the sites in less than a month. The Wady Ryan and a number of Nile valley reservoirs were discussed, the majority of the commission finally agreeing upon the Assuan site.

The Nile, from the town of Assuan to the dam site, is broken into many irregular channels. The bed and banks of the river are largely composed of granite. The first cataract of the Nile begins where the water first encounters the granite. Engineers agreed that the dam should be built in this locality, but as to its exact line there was a great deal of discussion. Mr. Willcocks recommended that it be of irregular alignment, running from one island to another, where his studies indicated that the granite was solid, thus affording a good foundation; but the dam as finally built is straight, and crosses the river where rapids first appear. It was originally planned to make the dam 100 feet high, but when it was found that a dam of this height would cause the submersion of the temples on the island of Philae it was determined, in view of the protests of those interested in the preservation of these ruins, to reduce the height 30 feet, although it is possible that it may still be raised to 100 feet. This would give the reservoir a storage capacity two or three times greater than it now has, while the ratio between the cost of the work and the volume of water impounded would be greatly reduced. (Pls. XX and XXI.)

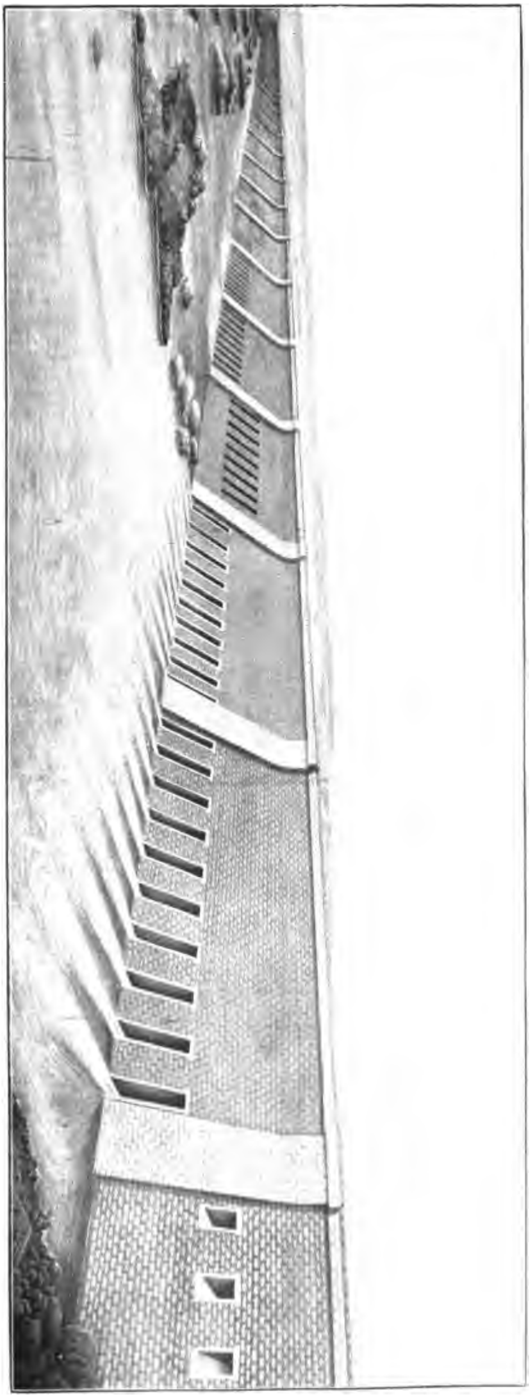
The dam is 70 feet high, 6,400 feet long, 23 feet wide on top, and 82 feet wide on the bottom at the deepest part. It contains approximately 1,000,000 cubic yards of masonry. The depth of water at the



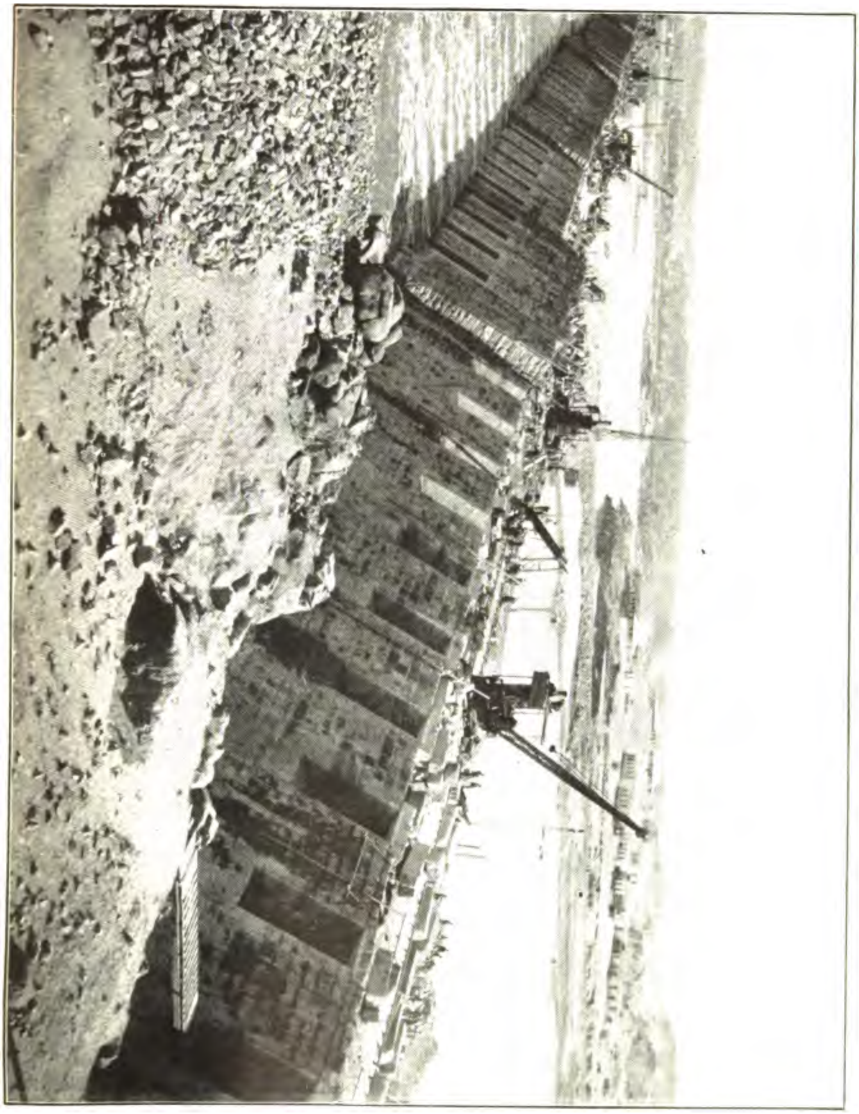
MAP COMPARING THE NILE VALLEY WITH THAT OF THE PLATTE RIVER.



MAP SHOWING THE ASSUAN DAM ACROSS THE NILE.



THE ASSUAN DAM.



WESTERN END OF ASSUAN DAM FROM DOWNSTREAM, JANUARY 7, 1902.

dam will be 65.6 feet when the reservoir is full. The cross section of the dam shown herewith (fig. 8) needs but little explanation. The roadway running along the top of that portion of the dam containing sluiceways is 16.4 feet wide. A large part of the eastern end of the dam, containing no sluiceways, is narrower, and the roadway there is

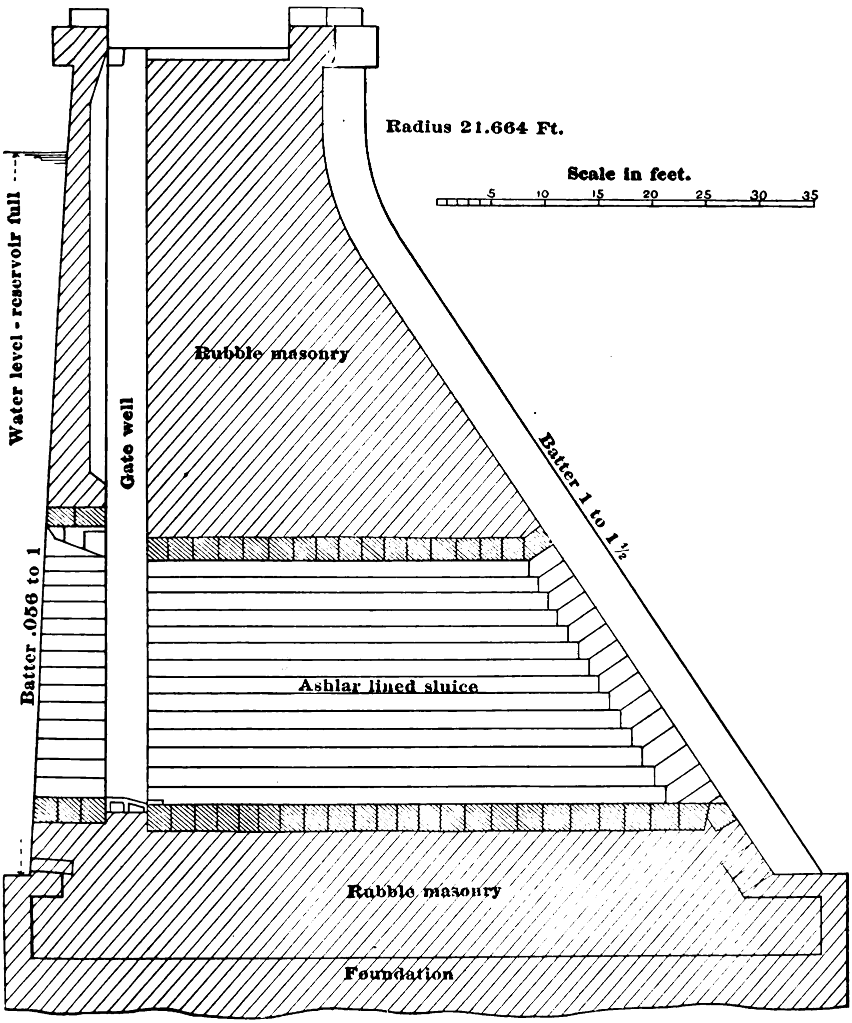


FIG. 8.—Cross section of Assuan dam.

reduced to 9.8 feet. The rubble masonry of the body of the dam is laid in 4 to 1 cement mortar, and the downstream slope is faced with squared rubble laid in the same mortar and pointed in 2 to 1 cement mortar. The upstream slope, being submerged a large part of the year, is faced with squared rubble laid in 2 to 1 cement mortar and pointed in the same. The batir of the lower slope of the dam is 1 to 1½.

Buttresses 3.75 feet thick and 26 feet wide are located between each set of 10 sluiceways, or about 240 feet apart. The buttresses were added rather for the sake of appearance than to increase the strength of the wall. The four locks at the western end of the dam are each 260 feet long and 31 feet wide. They will enable small boats to pass at nearly any time during the year.

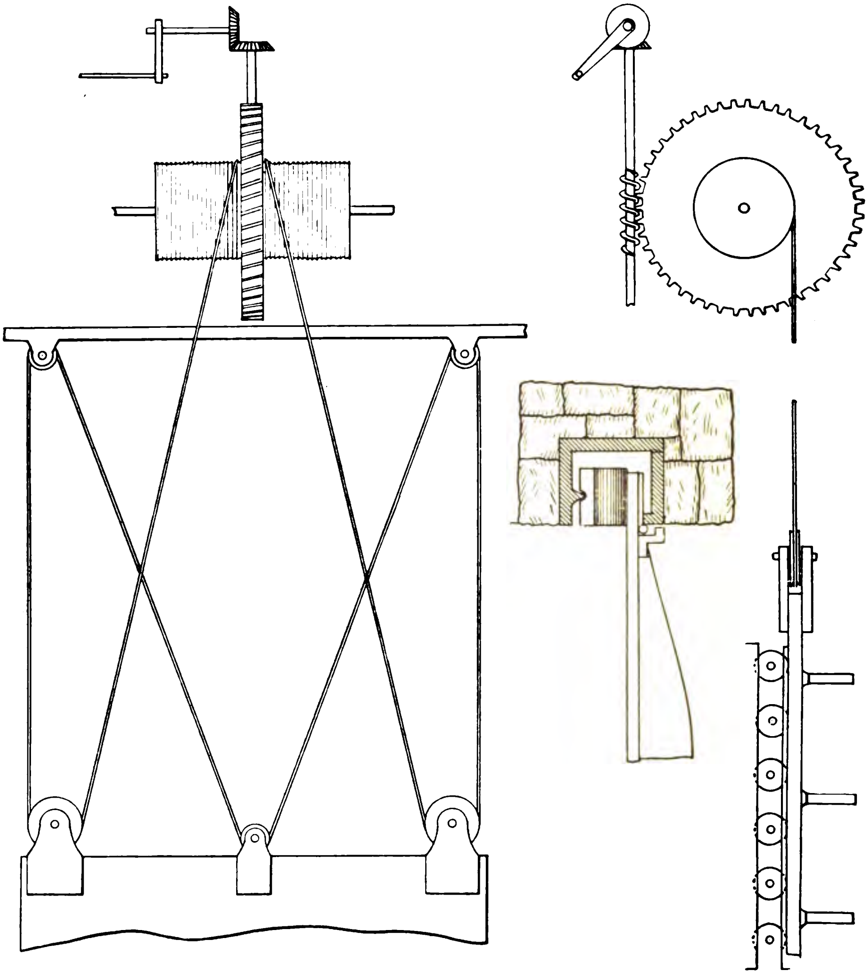


FIG. 9.—Details of apparatus for raising gates, Assuan dam

There are 180 sluiceways through the dam. Of these 65 have been placed with their sills practically on a level with the bed of the river. Forty of these low sluiceways are lined with cast iron (Pl. XXII, fig. 1), all others being lined with ashlar masonry. The cast iron is not considered as durable as the granite, but by employing it the work was much hastened, so that the sluiceways commenced at the end of one

high-water season could be finished before the flood again appeared. Seventy-five sluiceways have their sills 14.76 feet above the bed of the river. Of the latter 25 are supplied with roller gates and the remaining 50 have simply sliding gates, to be operated only when the head of water against them is small. Eighteen sluiceways have been placed 27.88 feet and 22 sluiceways 41 feet above the bed of the river. All of the sluiceways except the upper 40 are 6.56 feet wide and 22.96 feet high. The upper sluiceways have the same width but are only one-half as high. The rollers lie between paths on the gates and paths fastened to the masonry of the dam. The gates themselves are built up of steel plates, stiffened by rolled steel joists, which in turn are bolted to the cast-iron roller path beams. The following description of the gates and gearing for raising them has been furnished by Ransomes & Rapier, Limited, the manufacturers:

The gates are suspended by steel-wire ropes passing around pulleys so as to give 10 parts of rope. The two ends of the rope are wound upon a crab barrel placed at the side of the roadway at the top of the dam. The crab gear is such that one man can operate each gate with the full head of water against it, the gate not being in any way counterbalanced. (Fig. 9.)

Cast-iron grooves are built into the dam in order to provide the necessary space for the gates to work in. These are cast in sections and bolted together in place. A cast-iron sill piece and a cast-iron lintel form the top and bottom of the sluiceway opening. An arched roof casting supports the masonry over the entrance to the culvert in front of the sluiceway.

Owing to the cutting nature of the silt in the Nile water, it has been thought advisable to provide stanching rods on each side of the gate and also in the lintel casting. These rods will make the gates practically water-tight when shut down.

In the case of the 50 sluiceways 14.76 feet above the bed of the river, which are without rollers, the gates slide against the planed faces of the groove castings and are made water-tight against the faces, and also on the sill when the gates are completely lowered. The top is rendered water-tight by an adjustable bar bolted to the gate which lowers onto a projection from the lintel when the gate is in its final position.

The location of the sluiceways on the high level will permit the water of the reservoir to be controlled without its being necessary to manipulate the other gates, which will withstand a pressure of 300 tons when the reservoir is full. Toward the 1st of December of each year the lowest 65 and the 50 ordinary gates 14.76 feet above will be closed. The reservoir will immediately begin to fill, and the 25 sluiceways furnished with Stoney gates will be slowly closed as the discharge of the Nile warrants. It is hoped that in this way the reservoir may be entirely filled without appreciably affecting the flow of the river. The upper gates will be the last to be closed while the reservoir is filling and the first to be opened when the water is turned back into the Nile in May. The sluiceways furnished with Stoney gates will next be gradually opened, and all the gates will be raised by the middle of July, when high water appears. They will remain open

until the flood has practically disappeared and comparatively clear water again flows in the Nile.

Work on the foundation and lower parts of the dam had to be prosecuted during low Nile. The numerous channels into which the river is divided at the head of the first cataract favored this work. Temporary dams thrown across one channel turned the water into others, and, by thus changing about, each part of the foundation was completed and put in shape so that the next flood could pass over it without injury. Along the west margin of the river immediately above the dam it was found necessary to resort to riprapping, as the material is rather fine and the current sets in against that bank during high water. The greatest difficulty in the construction of the dam was to find stable material upon which to place the foundation. In one of the channels the partly decomposed granite had to be excavated to a depth of 60 feet below the bed of the river (Pl. XXII, fig. 2), making the total height of the dam at this point over 120 feet. The neighboring country supplied a fine quality of granite in unlimited quantities. The Egyptian Railway connects directly with steamers at Alexandria, and cement was delivered at Shellal, within 2 miles of the dam site. The contractor built light railways from the dam to Shellal and to the quarries. In this way the stone, cement, and other supplies were brought to the point where needed and were lifted direct from the cars to their final positions in the dam. The rubble masonry stone of which the interior of the dam is composed was carried up inclined planes by natives to the masons. The cement mortar for this work was mixed alongside the dam and handled in the same manner. The large dimension stone of which the face of the dam is constructed was cut at the quarry and shipped as needed. The edges of the stone were protected by wooden frames, and other precautions were taken to keep the corners true while the heavy blocks were being handled.

The first cost of the dam was $9,740,000, which, with interest, will be paid in 60 semiannual installments of $382,845.31 each, the first payment to be due July 1, 1903. This makes the final cost of the dam, including interest, $22,970,718.60. The cost of the work, not including the purchase of land which the reservoir covers or the repairs made to the temples of Philae, amounts to $11.26 per acre-foot of capacity. The ultimate cost to the people of Egypt, including interest charges, will be $26.56 per acre-foot. Egypt has also raised $5,746,600 for improving canal systems, especially those of Upper Egypt, so that the water supplied by the reservoir may be distributed.

As the water stored by the reservoir could not serve all the land which might be reclaimed in Egypt, it was decided to furnish water to the areas already under cultivation but which suffer from drought during the months of scarcity. That part of the valley lying between

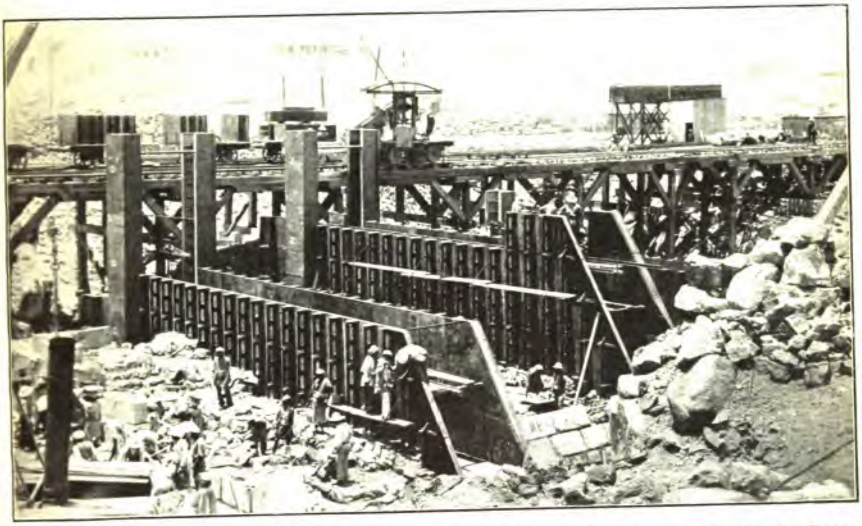


FIG. 1.—CAST-IRON LINING FOR SLUICEWAYS BEING PUT IN PLACE AT THE ASSUAN DAM.

FIG. 2.—DEEP FOUNDATION WORK NEAR WESTERN END OF ASSUAN DAM.

Assuan and Assiut was allotted 137,800 acre-feet. The lands between Assiut and Cairo were allotted 482,400 acre-feet. Gizeh province alone, near Cairo, was allotted 68,900 acre-feet. The territory north of Cairo, principally in the delta, was allotted 243,200 acre-feet. The sum of these figures is 863,400 acre-feet, the estimated capacity of the reservoir.

The engineers have estimated that about 70,000 acres can be irrigated from the reservoir between Assuan and Assiut, giving this area about 2 feet in depth, the water being measured in the reservoir and no allowance made for loss either through evaporation or seepage. One authority states that only one-third of the land is cultivated in any one season, which allows 210,000 acres to be served. It is extremely doubtful if over 70,000 acres can be served in this portion of Egypt during the three seasons of the year. If this area can be changed from flood to perennial irrigation the annual yield of the land will be increased at least $700,000. If 210,000 acres could be brought under perennial irrigation in this part of Upper Egypt, it would mean an increase in the returns to the farmer of about $2,100,000 and in the revenue of the state of about $60,000 per year.

The engineers hope to bring under perennial irrigation 458,000 acres of land lying between Assiut and Cairo. This would make an annual increase in the returns to the farmer of about $5,700,000 and in the revenue of the government of about $950,000. It is estimated that 160,000 acres can be brought under perennial irrigation in Gizeh province alone, yielding an annual increase in agricultural products of nearly $1,000,000 and about $300,000 to the government. By the perennial irrigation of 120,000 acres in the delta it is hoped to increase the annual returns from agriculture there by about $3,000,000 and the revenue through taxation by about $400,000.

In addition to the direct benefits from the reservoir, it is estimated that an average of $1,000,000 will be saved each year on the cotton crop. One year in five the Nile is so low that about $5,000,000 is lost by a failure of a portion of this crop. Besides this, about $5,000,000 will ultimately be realized from the sale of government land brought under perennial irrigation. It is believed that the water stored in the Assuan reservoir will add annually to the wealth of the country a total of $11,000,000. Land which can be perennially irrigated rents about $5 per acre higher than that which depends upon inundation alone. As shown above, the taxes on perennially irrigated land are much higher than on land not so watered. It is expected that the semiannual payments on the reservoir will be met by the increased revenue from the lands deriving benefit from the stored water. In the words of Sir Alfred Milner, "The Egyptian Government is relieved from the difficulty of paying for the works until return is received from them; until, in other words, they pay for themselves."

There is no doubt but that land values have increased greatly since the construction of the reservoir began, and almost any irrigation project in Upper or Lower Egypt has no trouble in securing financial backing. This demand for farming land and the increasing number of capitalists interested in Egyptian agriculture led to a number of inquiries regarding the actual capacity of the reservoir. Engineers were detailed from foreign countries to visit the site of the reservoir and obtain figures to satisfy capitalists that the reservoir would accomplish what it was advertised to do. In this way, and through the annual reports of the government engineers, the Assuan dam has probably become better known throughout the world than any other work of equal importance. However, outside of the surveys in the immediate vicinity of the site of the dam, little has been done to determine the actual capacity of the reservoir. A survey was begun during the winter of 1901-2 to establish the boundary line of the reservoir when full.

THE ASSIUT DAM.

The dam at Assiut was constructed for the purpose of raising the level of the water so that it would flow into large canals supplying water to land on the west side of the river. But one canal leaves the river at the dam. At Dirut, a few miles below Assiut, a wasteway has been built and a number of masonry regulators have been provided. At this place another channel comes in from the river. This latter channel is used only during high Nile. A number of divisions of the Ibraimia Canal at Dirut furnish water for the only perennial irrigation in Upper Egypt until the Assuan reservoir shall have become available. The most important canals below the regulators are the Ibraimia, running parallel with the Nile, and the Yusef, which parallels the Ibraimia for a distance, and ends in the Fayum province.

The Assiut dam resembles the barrage below Cairo somewhat, and, like the barrage, is founded upon soft material, which necessitated a very broad foundation. The general character of the dam is shown in Pl. XXIII. Its total length is 2,646 feet or about half a mile. The height of the roadway above the bed of the river is 44.5 feet. The piers supporting the roadway are 6.56 feet thick. Every ninth pier is 13.1 feet thick. The sluiceways are 16.5 feet wide. The depth to which water will flow through the archways during high Nile is 33.5 feet. Two gates, each 7.8 feet high, were provided for each sluiceway. When these are in position they are capable of increasing the depth of water about 10 feet. The gates are raised by a traveling winch which can be moved to any point along the dam. It is the supposition that the gates will not need to be lowered until the latter part of April each year, and they will be raised before the appearance of high water in July. During high Nile all sediment which may have collected above

the dam between April and July will be washed away. A lock has been provided at the western end of the dam.

This design has proved to be the best for dams where the material on which the foundation rests is not solid. It would doubtless give good service in the Platte, Arkansas, and other American rivers where the beds of the streams are similar to that of the Nile north of Assuan.

The Assiut dam cost $1,986,630. The stone was transported from quarries farther up the river and the cement and ironwork were brought from England. The Ibraimia Canal head gate, located on the west side of the river just upstream of the dam, cost $370,000. It is of the same general type as the dam except that it is provided with gates which are designed to withstand the flood water. As reservoir construction progresses on the upper reaches of the Nile, dams similar to the one just completed at Assiut will have to be erected wherever large canals are taken from the river.

DRAINAGE.

In Egypt, as elsewhere, irrigation and drainage go together. The Nile and the canals deposit material along their courses, and, after running in one channel for a long period, this deposit raises the channel above the level of the surrounding country. The water ultimately overflows their banks and runs across the low adjacent country, making for itself shorter routes to the sea. This change in channels has taken place many times since Egyptian history was first recorded.

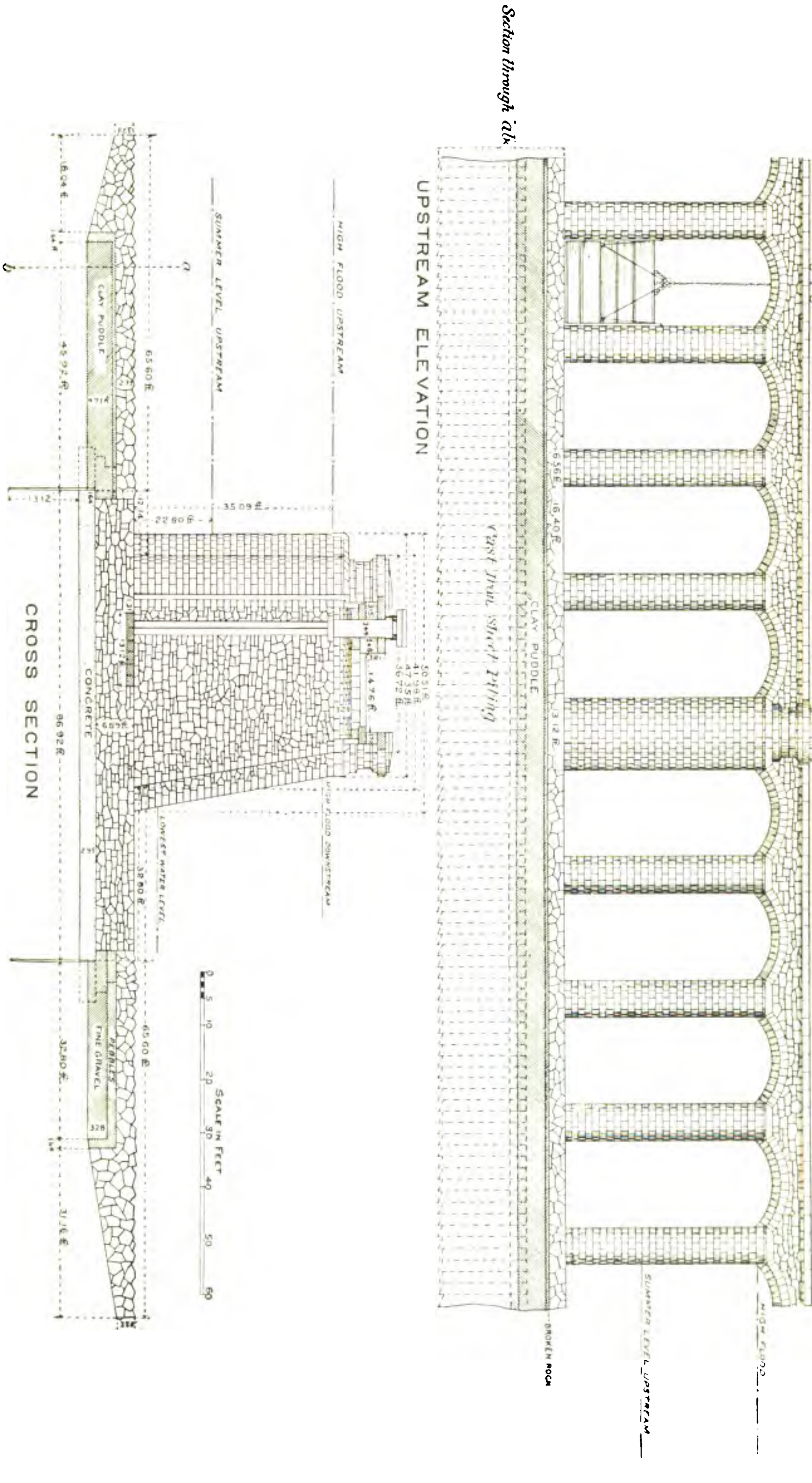
The delta is almost entirely separated from the sea by lakes which are supplied by rainfall, by water escaping from the river, by water from the canals, and by drainage from the fields. The boundary between these lakes and the sea is maintained by wave action of the Mediterranean. The process of draining them would be comparatively simple were it not that in some cases their surfaces are below sea level. Before perennial irrigation was generally extended throughout the delta, evaporation alone kept down the level of these lakes and they did not injure the bordering farming lands. Many drains had been dug, however, by the earlier irrigators. During the periods when Egypt was occupied by Turks, Arabians, and others, who paid but little attention to the condition of the farming class or to the success of agriculture, many drains were abandoned, while others were used as canals. Large areas, once good farming lands, reverted to salt marshes. It is with great difficulty that this land is being reclaimed at the present time. Into such a state of disorder had things drifted when the English took charge in 1882 that many of these early drains were used for canals and canals for drains. Many thousand acres which had previously been agricultural land reverted to the original swampy condition. These are being slowly reclaimed.

Immense pumping plants have been installed to remove the water from the surface, and drains have been dug. The surface of the ground is pulverized before fresh water is applied. After the water has dissolved some of the salts it is allowed to flow away. That which is absorbed by the soil reaches the drains and runs away by gravity or is lifted by pumps. This is an expensive and tedious process, but as soon as a portion of the salts are removed rice can be grown, and by careful use of the water the land continues to improve in quality. Much land has been thus treated and is now growing cotton and the more valuable crops of Egypt.

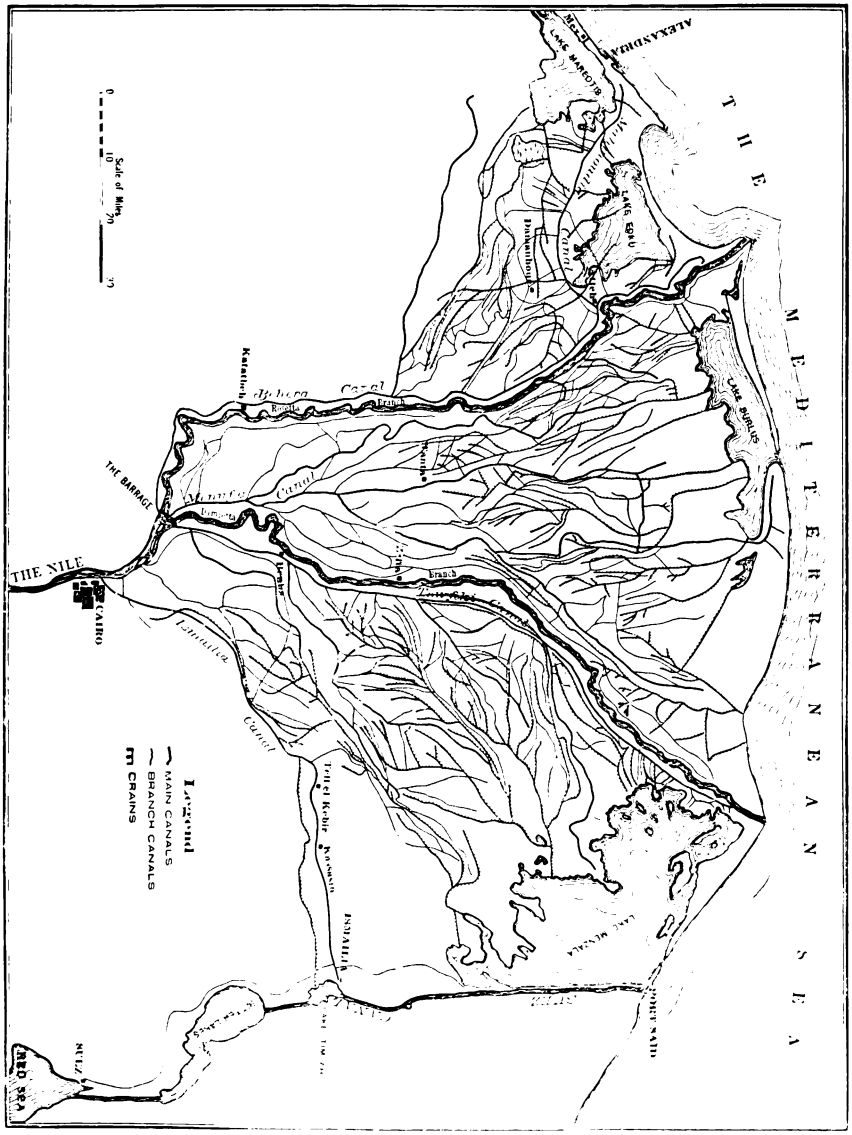
Since the occupation of the English $5,000,000 or $6,000,000 have been spent in drainage work. After the barrage was put in condition for service perennial irrigation in the delta was greatly stimulated, and it became necessary to provide for removing the added volume of water drained from the fields. Much of this water ran into channels tributary to the lakes. (Pl. XXIV.) The level of these gradually rose and threatened large areas of adjoining farming lands. Some of the lakes were drained by constructing simple works which permitted them to flow into the sea whenever there was sufficient difference in level. Lake Edku belongs to this class.

Lake Mareotis, near Alexandria, has probably given the most trouble. Its surface varies from 6½ to 11 feet below the sea level. Unless it can be maintained at least 8 feet below sea level large areas of adjoining lands already drained revert to their original condition. Until 1892 evaporation kept the level of the lake at a satisfactory height and pumping was not practiced. A pumping plant was installed in the winter of 1892–93, but, in spite of the fact that it discharged 200 cubic feet per second, the level of the lake was higher the following year than it had been for ten years before. This rise is attributed to an increased rainfall as well as to the increased volume of water from the irrigated lands. Soon after the installation of the first pumps others were added, until now the plant has a capacity of 1,200 cubic feet per second. The pumps are of the centrifugal pattern and are required to raise the water only about 10 feet. They operate from November until the following May or June. The cost of pumping is about 20 cents per acre-foot, or about 60 cents per 1,000,000 gallons.

The government owns two pumping plants besides the one at Lake Mareotis. One of these is for draining the Wady Tumilat, a narrow strip of land in a gap in the Arabian desert northeast of Cairo, where a considerable area has been injured by infiltration from the Ismailia Canal. The station is located at Kassasin. The other station, located at Atfeh and previously referred to, pumps water from the Nile into the Mahmoudia Canal.



DIVERSION DAM ACROSS THE NILE AT ASSIUT.



MAP OF LOWER EGYPT, SHOWING PRINCIPAL CANALS AND DRAINS.

LAWS AND REGULATIONS.

CONDITIONS TO BE CONSIDERED.

Egypt was the granary of the world four thousand years ago, and it is natural to look to such a country for model irrigation laws. Unfortunately irrigation in Egypt has developed under conditions different from those of any other country. The character of the Nile flood is such that until perennial irrigation was introduced there was no need of laws and regulations. Beyond some recent reforms therefore, the irrigation code of Egypt is as inapplicable to American conditions as are the sakiyeh and the wooden plow. While the present irrigation law of Egypt provides that certain canals, drains, and other improvements are the property of the government, the rights of neither the state nor the irrigator in the water of the Nile are defined. There are no special regulations regarding the use or the distribution of water, and no legal limit is placed on the volume applied to the fields. Measuring flumes and weirs are unknown. A reform is slowly being brought about through the gradual regulation of the capacity of the lifting devices, but it will be years before these furnish water in ratio to the area of the land irrigated. When one of these raising devices has to be replaced by a new one, or an altogether new plant is installed, the government prescribes the size of the pump, and in this way limits to some extent the volume of water furnished to the lands. Many large pumping plants have been installed, which will for years continue in use practically as they are to-day. Nearly all of these furnish water in excess of the quantity actually needed. The native farmer generally raises water by some of the ancient devices, and hence it is that he suffers by the introduction of the large pumping plants which rapidly deplete the water supply.

AUTHORITY OF OFFICIALS.

To enable the positions of the Egyptian irrigation officers to be understood it will be necessary to describe briefly the character of the government at the present time, treating only incidentally the complex foreign relations which have been entered into during the past thirty years. Egypt is divided into fourteen provinces; six of these are in the delta and eight in Upper Egypt. The Fayum is one of the latter, and includes two oases in the desert. Two oases are also included in the province of Assuit. Egypt, as a whole, may be compared to one of our smaller States, and the provinces with our counties. The accompanying map shows the location of each of these provinces and also the irrigation circles or districts. (Pl. I.)

The chief officer of each province is the governor. Under him is the council, which is made up of the vice-governor, the tax gatherer, a clerk, an accountant, a superintendent of police, a supervisor of

canals and public works, a head physician, and a supreme judge, who is a representative of the Mohammedan Church and is the authority on religious affairs. Some of the larger towns have independent governments similar to that of the provinces. Each province is divided into districts, over each of which there is a chief officer who is at all times under the orders of the governor of the province. Under these district officers come the sheiks, who are mayors or local magistrates. The larger towns are also divided into precincts, each of which has its magistrate.

In theory the government of Egypt is one of the most complicated in the world; in practice it is comparatively simple. The British minister plenipotentiary and his advisers are the real government. Native Egyptian officers have certain duties, but the English have all the authority. The theoretical heads of the government are the Sultan of Turkey, represented by the khedive; a number of foreign nations, including Great Britain; while the third and most important is Great Britain alone. The government therefore has three heads, only one of which is authoritative. Apparently the khedive is an absolute monarch; in reality he has no authority except such influence as the local representative of the Mohammedan Church in a Mohammedan country would naturally have. Then again, Egypt is a dependency of Turkey and pays $2,262,000 annually in tribute to Turkey, receiving nothing in return. While the Sultan has no political influence in Egypt, he is at the head of the Mohammedan Church. The finances of Egypt are largely controlled by a commission made up of representatives from foreign countries. Foreign judges sit in the mixed tribunals. Criminal suits against foreigners are tried in consular courts of the nationality of the accused, or he is returned to his own country and tried by a competent court there.

A decree of the khedive has no weight unless sanctioned by the British minister; neither can he veto a measure against the advice of that official. Before any measure can become a law it is prepared in the shape of a decree by one of the seven ministers. The minister of the interior is the prime minister and president of the council of ministers. Under him are the minister of public works, the minister of public instruction, the minister of foreign affairs, the minister of finance, the minister of justice, and the minister of war and marine. These ministers are native Egyptians, but the undersecretaries are British and control the policy of each department. These undersecretaries are advised by the British minister, and in this way his influence is felt through every department of the government. After a decree has been prepared by one of the ministers it is submitted to the council of ministers and the British financial adviser, or his delegate, who has a right to attend the meetings of the council. Any measure which provides for a change in the financial affairs of the government

this official has a right to veto. His power in this particular is absolute, and he is not required to give a reason for his actions. The business affairs between Egypt and Turkey are conducted by the prime minister and a special commissioner from Turkey.

Egypt has no popular government. No elections are held; hence the public takes little interest in the affairs of the government. In fact, public sentiment does not exist. Under the organic law of May, 1883, a representative assembly is provided for, but the same act contains so many restrictions that the functions of this body are entirely advisory. Some of the larger towns of Egypt and the fourteen provinces have something like local government, but, owing to the complicated nature of the control of Egypt, privileges of this kind can not be much extended. About all the advantage enjoyed by the provinces or these cities is that their local councils or assemblies may discuss measures which affect their communities. The council of ministers considers their recommendations when it meets, and in this way becomes acquainted with public needs as nearly as the council can interpret them.

The legislative council, composed of thirty members, meets at Cairo about once a month. Fourteen of the members of this council are named by the government, and the government reserves the right to delegate any other official to attend its meetings. Nothing can originate in this council, but it can examine the estimate of expenditures and discuss decrees which affect internal administration. The government is not required to accept amendments made by the legislative council, but the reasons for rejecting any amendment must be submitted in writing.

In addition to the legislative council, there is a body known as the "general assembly." It is composed of the ministers of state, the thirty members of the legislative council, and forty-six delegates, of whom thirty-five are chosen from the fourteen provincial assemblies and eleven are selected by the government. Before this body can meet the khedive must issue a decree calling for a session. The assembly should convene every two years; in practice its sessions are irregular, and when it meets its sittings are short and the business coming before it is of minor importance. It has no legislative privileges, but can veto any measures relating to taxation. No new taxes can be imposed without obtaining the consent of the general assembly. In fact, this is its only real power.

Regardless of the seemingly complicated nature of the government, the lawmaking power is quite simple. After the council of ministers has approved a decree it is transmitted to the khedive. It makes but little difference whether he signs it or not. His power of veto can not be exercised when it conflicts with the advice of the British minister. As these acts or decrees originate with the ministers, and the policies

of each minister are dictated by a British undersecretary, it is but seldom that measures are introduced that have not the indorsement of the English.

The irrigation officials are under the minister of public works and include an inspector-general of irrigation, one inspector of irrigation for Upper Egypt and one for Lower Egypt, and an inspector-general of reservoirs. These officials are all English, and all but the inspector-general of reservoirs have permanent positions, and his will doubtless last until reservoir construction has been completed. In the same rank with these officials stand six heads of the irrigation administration, who are native Egyptians. The head of the technical service is an Egyptian, and this branch is closely allied with the irrigation administration. To him are referred all technical questions relative to the issuance of licenses for pumps and other lifting devices. The survey department is in a way connected with the irrigation work. It has an English director. Two other departments, one dealing with towns and buildings and the other with antiquities, have but little to do with the irrigation administration. The two inspectors for Upper and Lower Egypt and the heads of the drawing and mapping divisions have their offices at Cairo.

Egypt is divided into irrigation districts, which, for convenience, are known as circles, and each circle has an inspector. The inspectors of the first and second circles have their offices at Cairo, the inspector of the third circle is at Alexandria, of the fourth at Mïneh, of the fifth at Keneh, and of the sixth at Sohag. The directors of the first, third, and fourth circles are English. The remaining three are Egyptian. The inspectors of the circles have immediate charge of cleaning canals, building smaller diversion works, repairing masonry structures, keeping gauge heights on the Nile and on canals, and dividing the water among canals in accordance with the area under each or as the inspector-general may otherwise instruct. Under these men are other officials, most of whom are natives, who travel about and see that the instructions of the inspectors of the circles are carried out. Ordinarily the responsibility of the engineer ends when the water is turned into the canals.

Every canal which serves more than two villages is held to be public, and comes directly under the irrigation administration. There is nothing in the law which requires a certain discharge to be supplied in the canal during any part of the year. There is nothing to prevent an irrigation official closing one canal or all at his pleasure. When water is supplied the canal the irrigator can use as much as he can lift and convey to his land. What he does not need he is free to waste. If the canal supplies too much water and floods adjoining land, or if it fails to supply enough to irrigate the farms depending on it, the irrigator has no recourse except to apply for a remission of a part or all of the tax ordinarily paid.

During the seasons of scarcity time rotations are enforced, over which the engineer has almost absolute control. The purpose of the administration is rather to save the more valuable crops than to protect the irrigators uniformly. This insures a maximum return to the treasury through taxation, but seldom affords an impartial and equitable division of the water. For instance, during some seasons rotations occur every four days; that is, irrigators are allowed to use the water a certain length of time and then be deprived of it for four days. During the warm seasons of the year, in June and July, four days of drought is sufficient to kill rice. The fellah who has planted this crop is the sufferer, and, although his taxes are remitted, he has no income from his land and must earn his living in some other way. It has been found necessary to modify the rotations under some of the longer canals because it often occurs that the water never reaches the lower end of a canal. Usually when water is turned into a canal it is allowed to run for a day before any one is permitted to divert it. In this way it will run a considerable distance before the volume is diminished to any great extent.

CAUSES OF LITIGATION.

Owing to the fact that the government controls the diversion and division of water there is no litigation between irrigators as to water rights. Cases are occasionally brought against the government because the water supply is short or because the size of the pump the engineers have permitted to be installed does not suffice for the irrigation of the lands it was intended to serve. These cases are becoming rare, as the engineers can generally show that the water was distributed as generously as the supply furnished by the river would warrant and that the volume made available by pumping, if properly used and distributed among the irrigators, would have sufficed for all.

Such suits, if the amount of money involved is small, go first before the native courts, where, at present, a government officer is usually looked upon with suspicion. For this reason an engineer outside of the government service can often greatly annoy the administration by making adverse reports or giving testimony in contradiction to that presented by the government engineers. As the irrigation cases in the courts are nearly all small and relate generally to rights of way and similar questions, the engineers have never had to give them much attention, and as the English have slowly instituted reforms in the court proceedings, just decrees and decisions are now the rule rather than the exception. The Egyptian engineers are also favored by the absence of any specific laws or regulations which would limit them to certain prescribed duties. With the power behind them which secured them their positions in the first place, they are enabled to take what-

ever decisive action is necessary and to institute such reforms as, in their judgment, are plainly necessary.

Another question which often leads to lawsuit against the government is the remission of taxes on the irrigated land or the reduction of taxes on the lands where the water has to be pumped. For instance, during the summer of 1901, only 38 acres out of a 50-acre farm were covered during the Nile flow, leaving 12 acres to be watered by pumping. As the owner failed to notify the government at the time that the water was not high enough to irrigate all of his land, he was taxed for the entire 50 acres as though it had all received the benefit of the high Nile. The government taxes on land which has to be irrigated by pumped water are only half as much as where the land is flooded. A suit of this kind is often expensive, and the testimony is generally quite voluminous. If a native brings the suit, and the area is small, involving a loss of less than $500, the case goes to a native court. If the land belongs to a foreigner the case goes to the mixed tribunals. In the former court the proceedings are in Arabic, and the records are published in Arabic and English. In the mixed tribunals the proceedings are generally in English, French, or Italian, and the proceedings are always published in French or Italian. If an appeal is taken from the decision of the mixed tribunals, the case goes to the court of appeals at Alexandria, where the proceedings are in French and are published in French.

When Mohammed Ali undertook the execution of the perennial irrigation works in Egypt, he carried on the reform as though he were the proprietor of all the land and water in Egypt. He fixed the rate of taxation, hired engineers to design the irrigation works and superintend the construction of the same. Where labor was wanted, he forced the fellaheen to leave their farms, either to excavate the canals or to work on the numerous irrigation structures connected therewith. The Egyptian farmer has long been used to this kind of treatment. In fact, he has never seen anything else until within the last fifty years, and it will take him a long time to entirely recover, even if the government makes it possible for him to do so. It is not surprising that a wise irrigation code has not developed in Egypt, when all of these conditions are considered. In a country where land titles were unknown, it would not be presumed that the rights of an irrigator would be recognized or protected.

Mohammed Ali, while not granting permanent title to agricultural land, instituted many reforms. Among these was the distribution of from 2½ to 5 or 6 acres of land to each person. This was made quite early in his reign, and in 1842 he permitted the holders to dispose of their land as they pleased. At no time, however, did they hold any actual title to the land they farmed. Together with the lack of titles and the weight of taxation, the fellaheen have in many cases been

forced to dispose of their land, and much of this is now included in the large estates.

Under Ismail large tracts were confiscated by the government. About a fifth of the agricultural area of Egypt is either directly or indirectly under the control of the state at the present time. Something over 500,000 acres have been in charge of the Daira Sanieh, which company has a contract with the government that stipulates that the land shall bring a fixed price when disposed of. About 96 per cent of the tillable land in this area is rented in small parcels to the peasantry. They pay on an average about $20 per acre per year in rentals. The land remaining unsold in 1905 reverts to the government. The land sold prior to that date goes largely to the small farmer, and whatever profit is made recompenses the company for its bringing the land under irrigation and placing it on the market. In this way a large area will return again to the fellaheen. About 440,000 acres are still included in the domains of the state. One hundred thousand acres of this land are located in Upper Egypt and the remainder in Lower Egypt. Probably 80,000 acres of this land will never be cultivated.

While Ismail Pasha inflicted many wrongs upon Egypt, one of his acts has resulted in benefit to the people. He was indirectly responsible for establishing the first titles to farming land in Egypt. He taxed the people to the limit, borrowed money with whatever credit he had, and without credit when this was exhausted. In an attempt to secure ready money he finally issued a decree providing that all persons who paid their taxes six years in advance would be given permanent titles to their land. Those who could afford to do so took advantage of this offer, and the titles thus obtained have since been recognized. The law was repealed in 1880, however, because it was not as good a financial measure as it had promised to be.

IRRIGATION AND DRAINAGE LAWS.

When the English engineers first undertook a study of Egyptian irrigation it was found that the law of Egypt was fragmentary and it was difficult for them to tell what provisions were in force. As early as December, 1885, the public works ministry issued regulations defining the respective powers of the governors of provinces and the inspectors of irrigation. These regulations (see p. 83) are still in force and are among the first reforms in irrigation law.

Such duties as the law of Egypt prescribes for the officers in charge of the division of water are not clearly defined. The relative powers of the director-general of irrigation and the inspector of Upper and Lower Egypt and the subordinates are not set forth. This leaves the authority wholly with the director-general and enables him to take such steps as may in his judgment be necessary during times of emer-

gency. There is nothing in the law which would govern the acts of the officials during times when rotations are necessary. They are not authorized to distribute the water so as to save any particular crop or to favor any locality or person. When a scarcity of water exists the relations between the governors of the provinces as prescribed by law have but little force. Water is distributed according to plans originating in Cairo and carried into effect by the inspectors for Upper and Lower Egypt and their subordinates. Even during such periods no attention is given to the necessities of the irrigators. Canals supplying water to the most valuable crops receive water in rotation, and each irrigator may raise and use as much as he can while there is water in his canal. If waste occurs, but little attention is paid to it. Under this system one canal may be favored this year and another the year following, depending upon which serves for the irrigation of the more valuable crops. The irrigator, it will be seen, has no recourse should his water supply fail. An appeal to the officers of the province might be heeded, but the engineers of the government would not be constrained to alter their plan of distribution.

It will be seen that the operation of such a system places all responsibility on the government. The defect in the system is that the people are not considered as having any rights, but are treated solely as a revenue-producing body, and a farmer who receives water one year has no assurance that he will be served the next year. There can be no stability in land values and no justice in the operation of a land-tax law under such conditions, although the rate of taxation is, to some extent, regulated by the value of the farm products. It seems that the time must come when the distribution will be fixed permanently. Under such a system the farmer would know, as soon as the stage of the river was reported from Assuan, as to whether he would be supplied or not. The completion of the reservoir system will do much toward settling this question, but it will be fifteen or twenty years before the farmers of Egypt can expect to receive entire relief.

The regulation of December, 1885 (see p. 83), fixes the relation between the governors of provinces and the irrigation officials. Section 1 provides that: "It is the duty of the governor to see that a just distribution of the water is made in the various districts composing his province." This is followed by a sentence which reduces his authority to reporting the needs of irrigators to the irrigation inspectors and listening to the complaints of the village chiefs.

The second section requires the inspectors to report to the governors, as well as to the minister of public works, should it be impossible to satisfy all demands for water.

Section 3 defines the duties and powers of the inspectors controlling the distribution of water and permits no gate to be operated ithout written orders from them. If the governor does not approve

of the action of the inspector or engineer he may appeal to the minister of the interior, but the order of the inspector will stand until countermanded by the higher official. During high Nile, or whenever work is necessary to avoid disaster, the orders of the governor supersede those of the engineer, and the engineer gives notice that discord exists, when the governor becomes responsible for what takes place. As the work is largely of an engineering character, it is only in rare cases that the governor prefers to take charge in the field.

The classification of improvement works provided for in articles 9 and 10 is worthy of notice. The governor has nothing to do with awarding the contracts for excavation requiring the services of more than 1,000 men, masonry work costing more than $974, or work where machinery is necessary. The law provides, however, that the governor shall be notified as to the character of the contract, and he has the privilege of reporting any failure on the part of the contractor to the engineer. In smaller improvement works the governor and engineer work together, selecting the contractor and supervising the work, the governor being the judge as to the reliability of bidders.

This regulation not only prepared the way for the irrigation laws that were to follow, but made it much easier to introduce reform measures regarding the corvée. As soon as the contractors on large enterprises were brought directly under the minister of public works and his assistants a solution of some of the labor problems could be undertaken. It was supposed at the time the regulation went into force that the use of machinery would go a long way toward reducing the labor of the corvée, but experience has not proven this to be the case.

While the need of better laws was evident to the engineers under the Egyptian Government, it was impossible or impracticable to bring about the enactment of a fairly comprehensive code until 1894.

The first article of this decree (see p. 85) defines a canal as a waterway which supplies more than two villages. These are public and are maintained by the government. A ditch is a channel which provides water for one or two villages, or for land belonging to one person or family, even if located in several villages. These latter are private property and must be maintained by those deriving benefit therefrom, but the government may clean them should the owners neglect to do so and tax the cost against the owners. As the number of irrigators under any canal increase, the necessity for government control in this respect evidently becomes greater.

Drains are classified in much the same manner as are ditches and canals. If a drain serves but one or two villages it is considered as a private work, unless it serves more than 2,000 acres. In the latter case or when it serves more than two villages it is considered public. Drains are maintained under the same regulation as are canals and ditches. This is probably due to the difficulty of distributing the work

of maintenance fairly among the owners. A provision has therefore been inserted in article 2 under which any ditch may be considered as public property should it serve for the irrigation of as much as 1,000 acres belonging to several persons.

Embankments and levees for protecting the country against the flood of the Nile are considered public property. These are maintained by the government.

Article 6 and many others of this decree have been recommended by the inspectors. During the first ten or twelve years of English occupation the provisions of section 6 would have been of great benefit in many cases. It stipulates that the owners of lands through which a public ditch passes can not destroy the same in order to make the land tillable without the written consent of the persons depending on the canal.

If it is necessary to close a canal for repairs or in order to give the water to others who are in greater need, irrigators can collect no indemnity from the government for the loss occasioned by a lack of water.

Article 8 is particularly interesting to those who have made a study of public supervision of water. One of the first necessities under such supervision is that the State shall have authority to limit the diversion of water when further canal construction may injure users already on the ground. Even in Egypt, where the Nile furnishes an almost unlimited supply during a large portion of the year, it has been found necessary to limit construction work where the rights of others are threatened. The intent of the law throughout is to distribute the cost of irrigation works in proportion to the benefits received by each user. This is well illustrated in the article under discussion. If a permit is granted authorizing the construction of a ditch others may use the works, providing they pay toward the cost of construction and maintenance in proportion to the benefits they are to receive.

The procedure for condemning lands for right of way for canals and ditches is set forth in article 9.

The value of farming land in Egypt is well illustrated by the provision of article 10 relating to enlargements of existing ditches. A right of way does not give the canal owners title to land lying on either side of the channel; hence when enlargement is contemplated it is necessary to condemn the additional land that must be used for the enlargement.

Article 12 relates to the diversion of water from canals. No lateral can be taken from a canal without the approval of the inspector, but if it is desired to install a sakiyeh the chief engineer decides the matter, and also designates the location of the lateral or sakiyeh. Permits are

applied for and granted under provisions of the decree of March 8, 1881.

Where a ditch, canal, or drain becomes a detriment to agriculture in any way, it may be filled in at the request of the owners of adjoining property, providing another watercourse can be used in its place without injuring other lands.

Article 14 illustrated the necessity of limiting the size of ditches and head gates to the dimensions necessary for serving the lands irrigated therefrom. If water were measured in Egypt as it is in some of the irrigated districts of the United States there would be no necessity for such restrictions. The time and money spent in changing the dimensions of canals and masonry regulating works would go far toward maintaining an adequate system of discharge measurements.

The close relation between irrigation and drainage is evident throughout the decree. Article 15 sets forth the procedure for locating a drain when the party to be benefited and the party through whose land the drain is to pass fail to come to an understanding.

The provision of article 19 is interesting when compared with the laws of some of the Western States. The article relates to the breaking of ditch banks, embankments, etc., and prescribes that if such an offense is committed complaint is made to the governor, who refers the matter to the inspector or chief engineer, who makes an examination of the ground, after having given at least fourteen days' notice of the examination. If the accused is found guilty he is required to restore the property or bear the expense of such work as may be necessary to restore it. In some of our States the fact that the water has been used is prima facia evidence that a ditch bank has been cut or a head gate has been tampered with. No notice is necessary and the water commissioner has police authority and can arrest the offender at once.

Another example illustrates how slowly the law is carried into effect in Egypt. If in the judgment of the engineer a small gate needs repairs, forty days' notice must be given the interested parties, that they may remedy it. If the work is not accomplished in the time, another period of forty days is allowed. If the parties still fail to perform the work the government has it done at the expense of the owners.

The decree does not define the rights of irrigators, the unit of measurement, or the basis upon which the water shall be divided among claimants, while other details of seeming less importance to us have been fully set forth.

The Egyptian government can compel the owner of land through which a canal runs to remove trees which are found to interfere with the full flow of water in the canal. It permits cultivation of a canal

and its banks under certain restrictions, but assumes no responsibility and no claim can be brought against it should the crops be lost or damaged. If the bank is needed for a highway or other purposes, no procedure is necessary in order to convert it into such, and the farmer who may have planted crops thereon has no recourse.

The articles relating to offenses and prescribing penalties therefor indicate that the engineers who framed the law desired to cover all offenses which had been called to their attention during the previous ten or twelve years. The sections referring to navigation are interesting in so far as they show the importance of the canals to the internal commerce of the country. The decree is given in full in Appendix I.

INSTALLATION OF WATER-RAISING DEVICES.

The decree of March 8, 1881, relative to the installation of machines for raising water, propelled by steam, by a current of water, or by the wind, provides that persons intending to erect such devices shall first apply for a permit, which application is approved or rejected, as the minister of public works or the head of the technical commission may decide. The decree exhibits plainly the attitude of the government toward the user of water. In article 7 it is stated that the approval of the permit carries with it no assurance from the government that water will be supplied the water-raising device. In other words, the government may approve of the installation of a water-raising device on a canal or a branch of the Nile where the water supply is inadequate. The government does not keep itself informed as to the actual discharge of the various waterways which serve the irrigator, nor do the irrigation officials know the capacity of the water-raising devices which are already in operation. After application has been made for a permit to establish a water-raising device one of the officials of the technical department makes an examination of the site where it is proposed to erect the machine. The approval or rejection of the application generally depends upon the report of this officer. When the application is granted a permit is given the applicant. The technical department keeps a supply of the permit blanks, which are bound in book form. The stubs of these blanks contain the permit in full, one side of the sheet being printed in French and the other side in Arabic. The permit itself, which is torn from the stub when the application is approved, is printed in Arabic only. On the reverse of the permit are extracts from the law relating to the installation of machines for raising water. These extracts are taken from the decree of March 8, 1881, and from the decree of April 6, 1881. The form of permit is as follows:

[Form No. 28 T. P.]

MINISTER OF PUBLIC WORKS.
TECHNICAL SERVICE.

No. ——.

Regular permit for stationary water-raising device. } Certificate.

Permit No. ——.

NAME OF APPLICANT.

————————————

————————————

CAPACITY OF THE DEVICE.

————————————

————————————

CANAL.

————————————

The applicant acknowledges receipt of this permit, together with a copy of the agreements and conditions imposed and of the design.

Cairo, ——— ——, 189—.

Correctly translated.

Cairo, ——— ——, 189—.

Mr. ——— ———, residing at ———, province of ———, is authorized, under the decree of March 8 and the rules of April 6, 1881, relative to water-raising devices, and according to the report of the ——— circle of irrigation, under date of ——— at ——— in ———, province of ———, ——— water-raising device ——— having a capacity of ——— H. P., intended to propel a pump for ——— acres, appurtenant to ———.

The device will be ——— on the ——— according to the design accepted by the applicant and in conformity with the agreements and conditions imposed by the aforesaid report, a copy of which, together with a copy of the design, is attached hereto.

The applicant hereby agrees to abide by the provisions of this permit and also by the instructions that will be given him by the said circle of irrigation, to which this permit must be shown whenever it is requested.

A failure to abide by the conditions and obligations imposed by this permit will release the undersigned from all provisions of this permit, without prejudicing the right which the government reserves to recover damages and reimbursement for expenses incurred. (Article 4 of the decree of March 8, 1881.)

Done at Cairo, ——— ——, 189—.

——— ———.
Chief of Technical Service.

Accepted by the undersigned applicant.
Cairo, ——— ——, 189—.
Approved.
Cairo, ——— ——, 189—.

This permit is of special interest because it is the only form which is recognized by the Egyptian irrigation law. It is the only paper which the government gives an irrigator that recognizes in any way the right to divert and use water. It will be noticed that the permit states the horsepower of the engine which propels the pump and the area of the land proposed to be irrigated. It gives no information regarding the height of the lift, the size of the pump, or the efficiency of the engine.

The decree relating to the installation of water-lifting machinery other than that just described (Appendix II, p. 96) is of special interest, and is of as much importance as any of the laws or regulations governing the use of water. The original decree was issued in 1881, and its provisions were extended in 1890. Any person may still construct and maintain a sakiyeh, a shaduf, or other water-lifting device, except those mentioned in article 1 of the decree of 1881, upon the banks of the Nile. Permission must be obtained from the government before water-lifting devices of any kind may be erected on the banks of canals. As the Nile in many respects differs but little from many of the canals, it is rather strange that this distinction has been made. The levees are more difficult to maintain than are the banks of the canals. Both classes of channels are public property, and most canals, as well as the river, are navigable. Navigation interests, how-

ever, are secondary to the needs of the irrigator, as is shown in the inconvenience to which river boatmen are subjected when the entire discharge of the Nile is turned into the large canals in the delta.

DRAINAGE.

The most important drainage work in Egypt is prosecuted by the government. A large part of the main drains and the largest of the pumping plants are therefore under its control. However, there are a number of large holdings, both in the delta and in Upper Egypt, where drainage is necessary. The government has also disposed of a number of tracts under condition that the land be reclaimed and improved so as to yield a revenue to the treasury. There are to-day large areas in the delta which must be drained before as much of Lower Egypt will be cultivated as was farmed before the invasion of the Turks, who permitted the drainage system to deteriorate. The Société du Béhèra, owning lands near Alexandria, has done much in the line of reclamation through drainage. Water is first drawn off by drains or by pumping, and large volumes of fresh water are applied. The surface is kept well cultivated, and gradually the salts are removed to such an extent that rice can be grown. After a few years of rice cultivation more valuable crops can be substituted.

In 1880 there were about 438,000 acres of public land outside of that which had recently been acquired from the khedival estates and put in charge of the Daira Sanieh administration. In 1899 this area had decreased to 210,000 acres, the remainder having been sold to farmers. In 1880 the Daira Sanieh administration controlled about 520,000 acres. In 1899 they had but 302,000 acres remaining.

As a considerable portion of this land required drainage works, it became necessary for the government to enact laws which should place the work partially under government control. It was essential that the government engineers should have authority to direct this reclamation, so that the systems planned and constructed by private parties should supplement rather than interfere with the work already performed by the government. Two decrees have been rendered relating to drainage. One was issued February 21, 1894, the other not until April 26, 1900. The decrees in full are given in Appendix III, p. 99.

THE CORVÉE.

The system of forced and unpaid labor known as the corvée has always been an important factor in all kinds of public construction in Egypt. From building the Pyramids to digging the Suez Canal or the excavation of a small drain, the corvée has been called into service. The labor of the corvée has made Egypt renowned for the products of the soil.

The conditions under which such a system has obtained a foothold in Egypt are largely responsible for the adoption of existing laws and regulations governing the use of water. The difference in the standing of farmers in the United States and in Egypt is almost wholly produced by the operation of the corvée regulations. If we are to make it clear as to why certain laws and practices are particularly well adapted to Egypt and not suited to arid America, the relation between the farmers called into the corvée service and the governing classes should be set forth in some detail.[a] Formerly the corvée was called upon for all kinds of public and private service. At present the system must be considered as an intermediate step between slavery and freedom; many changes for the better have been introduced during the past one hundred years and the future independence of the Egyptian farmer seems assured.

But little has been recorded of the character of the corvée during the early history of Egypt. The immense masonry monuments and temples, as well as the irrigation works which still exists, show how the unpaid labor was utilized. Up to the time of Joseph, some 1750 years B. C., the practice was recognized, and abuses became common after the system of slavery inaugurated under his administration came into full effect. The government owned the people and everything in Egypt from that time until during the early part of the nineteenth century. Some of the recent reports dealing with the use and abuse of this free labor enable us to realize to what extent the fellah has been imposed upon. The following report on forced labor by Mr. H. Villiers Stuart in March, 1883, sets forth the faults in the system at that time:

FORCED LABOR IN THE DELTA.

The complaints made upon this subject are that the apportionment is arbitrary and capricious, poor districts being required to furnish most and wealthy districts fewest laborers.

The richer class of landowners is also entirely exempt. They suggest that in lieu of the present system there should be a proportionate labor rate upon all land alike, instead of throwing the burden upon those least able to bear it.

Every landowner up to 100 acres is liable to forced labor; but he may, if he likes, pay a substitute. Some go and work themselves and some send substitutes. Those who possess no land are not liable.

Those who are liable get no pay whatever for their work; neither does the government provide them with any food whatever. Their friends at home have to send them food from their villages. Usually bread dried in the sun is their sole nourishment. It is sent in sacks, a couple of men from each village being deputed to convey it to the scene of operation. They have also to find their own tools and baskets.

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[a] The system has had great influence on the practice of irrigation and has made necessary the enactment of laws which would not be applicable in countries where the same conditions do not exist. In discussing the customs of the people of Egypt and the irrigation law there in operation, it should be borne in mind that regulations which might operate satisfactorily there would fail in the United States where authority comes from the people.

As a matter of fact, their hands are often their only tools. With these they load the baskets and excavate the soil. No shelter is provided for them at night nor any covering. A certain number of overseers are appointed. These are armed with sticks and superintend the work.

One complaint made universally was that instead of allowing the men of each district to work in their own districts the practice was to send them to distant parts of the province, thus needlessly increasing the difficulty and cost of feeding them and ministering to their wants.

Common sense would seem to suggest employment on the canals and embankments in their own neighborhood by preference, because they would then have a direct personal interest in the work.

They complained that there was much bribery and corruption connected with the appointment of the forced labor, wealthy communities thus purchasing partial exemptions at the expense of those who were too poor to bribe high enough. They said that this was the real reason why the system of letting each district find the labor for its own public works was not adopted, because that would be an obstacle to these corrupt exemptions.

All admitted forced labor to be a necessary institution in Egypt, the maintenance of canals and embankments being of vital importance, but there had been great abuses, and even now they assured me that men were still forced to labor on the estates of the government and of the wealthy pashas, but they said that now those so employed on the privileged lands received pay; previously they received none. This abuse, like many others, has been nominally abolished, but nevertheless continues, the sheiks conniving. Indeed, it is through their instrumentality alone that these abuses are possible.

FORCED LABOR IN UPPER EGYPT.

A cut about 18 feet deep has been made through a conglomerate of sand and gravel; this trench was flanked right and left by high embankments, consisting of the débris excavated.

From the summit of these ridges to the floor of the canal was from 35 to 40 feet deep; along the bottom and on the slopes right and left men swarmed thickly like bees on a honeycomb for a distance of about a mile in length.

The overseer told me that the entire forced labor of the province was concentrated there, 40,000 men in all; that they worked from sunrise to sunset without intermission except a brief interval at midday for a meal consisting of bread soaked in unfiltered Nile water. This bread was sent to them by their relatives, and they had a meal of it before commencing work and another at night. They have also to provide their own baskets for carrying the excavated soil. They were engaged in filling these baskets with gravel (using their fingers for the purpose), climbing the sides of the cut, and tipping them on the outer slope. The majority had no implements but their hands. A limited number had short picks a foot long, which they also have to provide, the government contributing nothing whatever.

The day was excessively hot, and not a breath of wind. The temperature in my cabin with all windows open was 82 degrees in the shade. At the bottom of that trench it was much hotter. I should estimate it at 95 degrees. There was absolutely no shade. In this fiery heat and glare and amid dust they toiled all day long. They were clad in calico, mostly reduced to rags by the work they were engaged in. They wore on their heads felt skull caps exactly like those represented as worn by workmen in fourth dynasty bas reliefs. They were barefooted. Their calico rags formed their only covering at night, and they slept on the bare ground in the open air without any kind of shelter, although the nights are often very cold. Among them were many overseers armed with sticks, with which they often struck the men while carrying loads on their heads, without any apparent reason. Many had sore fingers and sore feet, for there were sharp flints among the débris.

I have seen negro slaves at work on the cotton plantations of Cuba; I have also seen the convicts at work at Portland. The conditions under which all these labored were greatly preferable to those to which these Egyptian fellaheen were exposed, and it must be remembered that most of them own farms and constitute, in fact, the yeomanry of Upper Egypt.

What struck me most as I gazed on the toiling multitude was the pitiable waste of human labor, for one-fourth the number, with proper tools and appliances and sufficient food, and with intelligent and experienced foremen to direct them, could have done the work far better and more quickly than the ill-directed efforts of that mob of men, without implements, weak from scanty diet and exhausted by hardship. An English navvy would laugh at their work as excavators, but the conditions as to food, temperature, and exposure under which they work would kill him long before the month was out. Ophthalmia is one evil that results. I can not imagine a better receipt for the wholesale manufacture of this malady than to work men to exhaustion in fiery heat and glare and dust all day and then to expose them at night to the heavy dew and frosty temperature, lying on the bare ground in their calico dresses.

It must not be supposed that because the government pays nothing for it that therefore forced labor, as now conducted, is cheap; on the contrary, it is most costly to the country. Every man there withdrawn from the cultivation of his farm represents a family by so much impoverished.

One-half of the able-bodied population is engaged for between three and four months in the year in forced labor. That means that the second crop on their farms is reduced in productiveness by one-half; that on the lands where 4 ardebs (21.76 bushels) per acre could have been yielded had all the hands remained at home, only 2 are yielded owing to deficient irrigation when half the hands are withdrawn; that is to say, that it amounts to a tax of 21s. ($5.04) per acre on every acre devoted to second crops. Where land is rented, not owned, these second crops often constitute all the return the cultivator gets, rent and land tax entirely swallowing up the first; the price the government pays is the pauperization of the people and the reduction of their taxpaying capacity, but that is not the whole price. There are not men enough in Egypt to cultivate it properly or to develop its resources fully; the government, grudging the cost of food and implements, is prodigal only in men, the very article that most needs here to be economized. If they can save the expense of tools by setting four or five men to do the work which one man with tools and food could easily accomplish, they send the five men and withhold the tools and food. I fear, also, that the sacrifice of men is not merely temporary; men can not be exposed with impunity to the hardships which I witnessed. The constitutions and health of many must be permanently impaired, even their lives shortened. Twenty thousand men are said to have perished in making the Mahmoudia Canal, and I can well believe it after what I witnessed near Keneh.

It must be accepted for a fact that forced labor exists with the consent of the great mass of the people of Egypt. I have heard them complain of this or that tax and suggest its abolition, and I have heard them complain of the unfair apportionment of forced labor in their district, but I never heard one single person of any class suggest the abolition of the forced-labor system. They admit it to be necessary, but it does not follow on that account that nothing can be done to reform its conditions. The first term of labor should be postponed till the first crops are thrashed out and sold and the second crops well established and less likely to suffer from defective irrigation. The men should be supplied by the government with nourishing food. Two or three intervals for food and rest should be allowed in the day, instead of only one. Proper implements for excavating should be supplied to them. Labor-saving machinery should be introduced where possible. Skilled foremen should direct the works. The men should be divided systematically into gangs, each gang with its own task marked out, instead of the desultory fashions which now prevail, for they work in a mob and every man is in his neighbor's way. Some shelter ought to be

arranged for the night, if possible, or, at any rate, they should be supplied with a warm wrap, no matter how coarse; old sacks would be better than nothing.

REFORM OF THE CORVÉE SYSTEM.

When the English engineers began their work, in 1883, they found that all earthwork necessary in the construction and cleaning of canals was performed by this kind of labor. Under the original basin system, before the farmer had a title to the land he cultivated and while he was simply a slave, this practice might have been excusable. There are no good reasons, however, why it should have been continued after the reforms introduced by Mohammed Ali were put in operation. Under the old system the farmer had nothing to do when there was no water, and he could do nothing during the flood. Under the perennial system some kind of farm work is in progress throughout the year, and if the farmer is taken away from his land the results are as serious to the taxgatherer as to him. Perennial canals require a great deal more labor to keep them in repair than do the ancient inundation canals. This is because the canals are deeper and carry water throughout the year. The whole agricultural population was formerly employed a large part of the year in keeping these canals in condition, although but a small portion of the people so engaged were directly interested in them. So long had the system been in force in Egypt that immediate reform was impossible. The increased security to land titles did much toward bringing about a change for the better. The first khedival decree relating to the corvée appeared in January, 1881.

Articles 1 to 4 of this decree prescribe what works shall be maintained by the public.

Article 5 provides that all male inhabitants of the country, of sound health, between the ages of 15 and 50 years, with the exception of those indicated in the following section, are subject to corvée duty.

Article 6: The following persons are exempt from corvée duty: Law students of the Koran; those who recite the Koran; persons engaged in teaching; students of the mosques and schools; persons attached to charitable institutions, shrines, convents, and hospitals; those in the service of the mosques, tombs, and holy places having distinct offices; priests, monks, rabbis, and persons attached to the service of churches, temples, cemeteries of the various sects and holding permanent positions; people having professions or trades who pay professional taxes and who exercise their calling; also fishermen and boatmen; the watchmen of the villages.

Article 7: Every person who is subject to corvée duty can redeem himself by furnishing a substitute. The following persons can redeem themselves by a payment in cash: Inhabitants of isolated settlements who have been included in the census; Bedouins who own land or cultivate the same and who have heretofore been exempt from such labor; the inhabitants of the villages working on the state domain and the

Daira Sanieh in Lower Egypt, wherever these administrations have more than 100 acres, on the condition that the land is not rented and that the ransomed men shall devote their labor to cultivation. Forced labor is obligatory from the inhabitants of the villages where rice is the predominating crop, or where the land tax is adjusted as it is for such villages, but the corvée duty of such inhabitants will be only half of that required from the inhabitants of other villages.

Article 8: Where a cash payment is permitted in lieu of services, about \$6 is required in Lower Egypt and about \$4 in Upper Egypt. After the year 1882 the amount of this payment shall be fixed annually, and the minister of public works shall so notify the governors of the provinces one month before the commencement of work. The conditions which shall affect the amount of this payment are the quantity of material to be moved and the time when it is necessary to perform the work.

Article 9: The minister of public works can, when he deems it necessary, withdraw the privilege of the payment of cash instead of labor as provided for in article 7, or he can substitute machine work for hand labor.

Article 10: The money received in each province from this source will be entered in a special register and deposited in the treasury of the province and kept at the disposal of the minister of public works. These sums can be spent only on works which have for their object reduction or suppression of the corvée.

Article 11: It is the duty of the minister of the interior to collect and keep in service those subject to the corvée.

The khedival decree issued in 1882 permitted the Arab farmers to redeem themselves from the corvée by a cash payment, and the same decree frees the Bedouins from this service entirely. Under the provisions of this decree those having political influence gradually secured relief from both the payment and the corvée service and the whole burden fell on the poorer classes. Early in 1885 some of the fellaheen of one of the districts applied for an investigation to be made of the corvée conditions. It was found in an examination of the corvée service from 145,000 acres that the entire number of men furnished came from 33,000 acres. The state lands included within this district redeemed about half of the renters, and the large landholders, who own about 59,000 acres, paid nothing and furnished no labor.

The partial reconstruction of the barrage in 1885 brought about the first real relief to the fellaheen. This structure not only furnished water for the farmer during the period of low Nile, but also enabled the discharge to be regulated in such a way as to reduce the volumes of silt which were annually deposited. In addition to this relief \$150,000 was spent in paying those who worked on certain canals. This was an experiment to see whether it was possible to relieve or wholly do away with forced labor. The work was entirely successful. Not only were

the inhabitants better satisfied to carry it on, but the work was better done, and the money reverted to those who bore the burden of the tax. This kind of work is carried on by contract, and each person is paid for the volume of earth he removes. Owing to the improved quality of hand labor it was possible to clean canals in which 125,000 cubic yards of silt had deposited. At first it was estimated that machinery would have to be employed when the volume exceeded 50,000 cubic yards for any one canal. In 1886 the first systematic work of cleaning the canals was undertaken by the government, and this was gradually extended until all earthwork was carried on without the employment of the corvée. The cost of cleaning the canals amounts to nearly $2,000,000 per year. While this is a serious drain on the treasury of the country, yet it is a long step in advance of the conditions which existed prior to the initiation of reform. The corvée is still called out to watch the banks of the Nile during high water.

A number of decrees have been issued dealing with details regulating the corvée service, but they are comparatively unimportant. On December 19, 1889, the following decree was rendered:

We, the khedive of Egypt, at the instance of our council of ministers and in view of the deliberations of the general assembly, decree:

ARTICLE 1. The corvée is suppressed throughout Egypt.

ARTICLE 2. The guardianship and charge over the dikes and other works, as well as all urgent measures in case of danger owing to the rise of the Nile, shall continue to be carried out at the expense of the inhabitants.

ARTICLE 3. The corvée and redemption tax are replaced by the establishment, both on Ushuri and Kharadji lands, of a special tax with a maximum tax of $0.214 per acre, the total produce of which shall not exceed $741,500 per annum.

The assessment of this tax shall be made by a further decree issued on proposal of our council of ministers, after consideration by the legislative council.

ARTICLE 4. The produce of this special tax shall, with the authority of the commissioners of the debt, be employed under the conditions prescribed by our decree of the 14th of June, 1889, for the sum of $1,235,750 provided for in the said decree.

ARTICLE 5. Our ministers of finance and public works are charged, in so far as they are each concerned, with the execution of the present decree.

Done at the palace of Abdin the 19th of December, 1889.

(Signed) MÉHÉMET TEWFIK.

By the Khedive:

The President of the Council of Ministers.
The Minister of Finance.
(Signed) RIAZ.
The Minister of Public Works.
(Signed) MOHAMED ZÉKI.

Many preliminary steps were necessary before this final decree could be rendered. Some of the foreign powers objected to increasing taxation for the purpose of relieving the fellaheen in this work. The French were particularly active in this opposition.

Although to-day the fellah is not imposed upon as he was twenty years ago, yet he does not enjoy liberty as we understand it. The work of watching the Nile levees during high water results in consid-

erable hardship to the farmer. The following table shows the number of men called out during the twenty years from 1880 to 1899, inclusive:

Number of men called on for corvée duty, 1880–1899.

Year.	Number of men.	Year.	Number of men.	Year.	Number of men.	Year.	Number of men.
1880	110,385	1885	125,936	1890	48,488	1895	36,782
1881	281,283	1886	95,093	1891	44,962	1896	25,794
1882	262,923	1887	87,120	1892	84,391	1897	11,069
1883	202,650	1888	58,788	1893	32,752	1898	34,770
1884	165,105	1889	49,904	1894	49,488	1899	17,564

The number of men needed in this work depends upon the stage of the Nile during flood. The higher the flood the more men are required to watch the banks during this critical period. The difference between this work and the cleaning of canals is that those employed in the latter service receive compensation fixed by the government. Service is compulsory in both cases. If an accident occurs to the government railway line, men are forced to leave their homes and put it in repair, and are paid for their services as the government may deem sufficient. It can not be said, therefore, that forced labor has been abolished. Those who are best acquainted with the conditions admit that the system has simply been modified and reformed.

CONCLUSIONS.

The climate of Egypt being mild, the needs of the people are easily satisfied; the population is dense and the individual holdings of land are small. Labor is cheap, enabling much to be accomplished by the use of crude implements which could be performed profitably in America only by the employment of modern machinery. The irrigation canals of Egpyt convey water to the farms, but the irrigator must raise the water for his fields. He has few other duties which demand his time and energy during the growing season, and therefore can use with profit machinery which requires a large expenditure of labor but little expenditure of money. In lifting water from the Nile the Egyptian deals with the same obstacles as the irrigator in many localities in the West where water can be secured at depths ranging from 10 to 25 feet, but there the resemblance ceases. The standard of living of the American irrigator is higher, his farm is larger, and the returns from an acre are less. He can not adopt water-raising devices of low efficiency like the shaduf or natali. The hoe, practically the only tool used in distributing water over the fields in Egypt, has no merit to the American farmer. We can not, therefore, learn much from the Egyptian irrigator.

Many of the irrigation structures of Egypt are models of their kind. The barrage below Cairo is one of the most interesting dams in the world. Its architecture reflects some of the recent political struggles in Egypt. The towers which embellish the dam should be classed

with the ruins bequeathed to the modern world by ancient Egypt. The barrage is a monument to the French engineers, while the fortifications along it remind us that it was only a few years ago that the caprice of the khedive overshadowed the designs of the engineer. The Assiut dam follows the general plan of the barrage below Cairo. The design of the dam at Assuan is new in Egypt as well as in the world. It marks the beginning of a great reservoir system which will ultimately control the waters of the Nile and furnish a supply to every arable district of Egypt. The head gates, waste gates, regulators, and bridges of the larger canals will always be objects of study for irrigation engineers of other countries.

The excellence of the recent irrigation works of Egypt is beyond question. The fame of the dam at Assuan has been heralded throughout the civilized world; but such works are costly. Before the distributary systems are perfected the cost of the system supplied by the Assuan reservoir will exceed $57 per acre of land irrigated. Such an outlay is not at present profitable in the United States. It is advisable, nevertheless, for us to study the larger irrigation works of Egypt, because it may be possible for American engineers to modify these designs to suit the needs of irrigation here. Many of the smaller details of construction can be readily introduced

The Nile is an easy stream to divide, hence laws for the economical distribution of water are not so severely tested as they will be on the streams of the arid West. Water is diverted only at the lower end of the Nile, and not from all its ramifying tributaries, as is the case on the Missouri and Colorado. In addition, Egypt is one of the few countries where the water supply can be made adequate for the needs of all by storage. This will not be possible in the United States except under rare conditions, where the area of irrigable land along a river affording the supply is comparatively limited. In Egypt the demand for land will in a few years exceed the demand for water. With us the area of irrigable land will ultimately be limited by the water supply.

The Egyptian irrigation law aims to bring about such a distribution of the water of the Nile that the country as a whole will produce the largest returns and the treasury receipts be the greatest. The irrigation laws of the Western States of the United States are framed to protect the individual farmer, and not for the purpose of producing revenue. This fundamental difference in the objects to be attained makes Egypt's administrative system inapplicable to this country. There does not seem to be any reason for changing our policy. On the contrary, it seems wise that our irrigation administration should promote the prosperity of the water user as far as practicable, so that we may say in the words of Ameni, as inscribed on his tomb at Beni Hassan, 50 miles above Cairo, "And behold, when the inundation was great, and the owners of the land became rich thereby, I laid no additional tax upon the fields."

APPENDICES.

Appendix 1.

Note.—The laws as given in these appendices are free translations of the texts, as given in La Législation en Matière Immobilière en Egypte, Le Caire, Imprimerie, Nationale, 1901.

POWERS OF THE GOVERNORS AND INSPECTORS OF IRRIGATION.

[Regulation of December, 1885, fixing the relation between the governors and inspectors of irrigation.]

(1) It is the duty of the governor to see that a just distribution of the water is made in the various districts composing his province. He will make known at an opportune time to the irrigation inspectors appointed by the minister of public works the places where more water is needed and at what times, and hear the complaints on such subjects as may be addressed to him by the chiefs of the villages.

(2) It is the duty of the inspectors to satisfy all demands as far as possible, and where they can not for any reason carry out these instructions they shall report the matter to the governor and communicate with the minister of public works. The governor on his part shall inform the minister of the interior, and the two ministers shall together take the matter under consideration and, if necessary, report it to the council.

At the beginning of each year the governor, with the agricultural council, which is assisted by the engineers, shall specify in the ordinary manner the various works which are to be executed and shall determine the number of the corvee necessary for cleaning canals and for construction.

In order that the governor may be able to undertake this work with full knowledge of the facts, the chief engineer shall report to him his estimates and calculations some days before the meeting of the agricultural council.

The governor shall put himself in direct communication with the chief engineer on all questions which may arise during the course of the year. If he does not obtain satisfaction he may appeal to the inspector, and, if necessary, to the minister of the interior.

(3) The technical control of the distribution of water, the partial or complete closing of gates, belong wholly to the inspectors, and nothing may be done without their written orders. Consequently, if the governor believes that it would be better to partially open or close any gate he must address the chief engineer, and, if necessary, the inspector, giving his reasons and all possible evidence. The engineer and inspector may be able to approve and act accordingly. If not, they must explain to the governor what facts and evidence the minister of the interior and the minister of public works should have in case the question is appealed to them.

(4) During high water in the Nile, or whenever necessary to avoid disaster, and when the governor does not have near him an engineer whom he may consult, it is the duty of the governor to do whatever in his judgment may be necessary, whether to throw stones in the water or to use any other means for adding to the security of

irrigation works. In such cases the governor should telegraph to the inspector immediately, requesting the aid of the chief engineer.

If the engineer of the province be present, he, and not the governor, directs what measures to adopt, and he is held responsible for the same.

If, however, the governor gives orders contrary to those of the local engineer, the latter must obey, but at the same time give notice that discord exists, after which the governor is responsible for what takes place.

The inspector shall arrange matters so that the governor may be accompanied as often as possible in his journeys along the levees and canals during high water by the chief engineer or some one delegated by him.

(5) The engineers are under the minister of public works, but they owe to the governor the respect due to the principal representative of the government in the province. They should respond to his demands and give him all the information he may desire. When the governor has reason to believe that the local engineer acts without or beyond the orders of the inspector in that which concerns the making of regulations relative to the use of water, which regulations must always be communicated to the governor and published, he must study with care the conduct of the engineer, make full inquiries regarding his acts as well as the acts of those under his orders, and shall make known to the inspector the results of these inquiries.

(6) No new work may be undertaken without the previous sanction of the council of ministers. Concerning important improvements which the inspector believes should be made in the irrigation or drainage of a region, he must act in concert with the governor, and in all cases they must inform the minister of the interior and the minister of public works, who shall be members of the council of ministers.

In public improvements and reforms of less importance it is the duty of the inspectors to personally inform the governor regarding what they propose to do, the effects of the proposed changes, and the obstacles which they will have to overcome. Notification in writing, either English or Arabic, is not sufficient for this, and the inspectors must never fail to explain their ideas at least by maps and diagrams. Because of his special knowledge of the agricultural interests the governor can and should indicate how the proposed work might occasion loss or damage to private or public property. The two ministers and the council must be informed also.

(7) The number of the corvée, as before stated, is determined by the agricultural council. The governor must decide as to the number of men who should be included in the corvée, and agree with the engineer as to the order in which the canals should be cleaned and the time for said work.

The governor is not to be called upon for the technical execution of the work; the chief engineer is alone answerable and bears all responsibility for the completed work.

The governor may, should there be occasion therefor, call upon the chief engineer to permit those of the corvée who have finished their work to return home.

(8) When, for any reason, the inspector desires to close a canal for more than fourteen days, he must inform the governor of his intention as soon as possible, so that the latter may present his objections if he has any.

(9) *Irrigation works.*—Irrigation works may be divided into two classes. The first class includes those for which bids are advertised in the official journal, which bids are submitted under the prevailing rules of the minister of public works. These works comprise all excavation requiring more than a thousand men per day, all masonry work costing more than £200 ($974), and all work in which machinery is necessary.

In work of this class the governor will not be consulted as to the choice of the contractor, but he shall be informed regarding the nature of the contract. During the execution of the work he must, if he deems necessary, call the attention of the engineer to the manner in which the contractor is executing the work.

(10) The second class covers the excavation and cleaning of small canals, small works where masonry is not needed, and repair of masonry works. Contractors shall submit bids to the governor for work of this class. The inspector shall submit to the governor a copy of the specifications. The bids shall be opened and a contractor chosen to the satisfaction of both the governor and the inspector or his assistant. It is not necessary to accept the lowest bid. In work of this class the governor must always judge as to the reliability of the bidders. The governor should, if possible, favor local contractors.

CANALS AND LEVEES.

[Decree of February 22, 1894, concerning regulations regarding canals and levees.]

PUBLIC CANALS AND LEVEES.

ARTICLE 1. The word "canal" refers to a water course which serves for the entire or partial irrigation of the lands of more than two villages. All canals of this kind are considered public property. They are generally constructed and maintained at government expense and are a part of the public domain.

The use and occupation of banks of canals are permitted only under certain restrictions laid down in article 21 of this decree.

PRIVATE DITCHES.

ARTICLE 2. By the word "rigole" is understood a water course which serves for the irrigation of the land of one or two villages or of land belonging to one person or to a single family living in one community even if belonging to several villages.

All rigoles are considered private property. The cost of construction and maintenance is borne by those who derive profit from the works.

In case of delay in cleaning these works the government may perform the work at the expense of the proprietors. The sum thus spent will be distributed by the governor in proportion to the taxes paid by each, and it will be collected in conformity with the provisions of the decree of March 25, 1880.

However, if a ditch serves for the irrigation of 1,000 acres belonging to one or several persons it can always, upon request of the owners, be considered a public waterway.

DRAINS.

ARTICLE 3. The word "drain" indicates a channel in the earth for carrying away rain water, drainage water, or water from irrigated fields.

A drain is public when it serves more than two villages; private when it serves one or two only, unless it drains a surface of more than 2,000 acres in area, when it is considered a public work, although it may be situated in one village.

The public drains are maintained by the government and the private drains by the parties interested. The provisions of the second paragraph of the preceding article are applicable to private drains.

WORKS FOR PROTECTION AGAINST INUNDATION.

ARTICLE 4. "Works for protection against inundation" are levees, transverse and longitudinal dikes, and all structures serving to protect farms and villages from the overflow of water.

These works are considered public property and are wholly under government control.

Private levees upon the banks of the Nile, or those which form the boundaries of the basins and which are constructed by the owners, must be maintained at the expense of those benefited.

POWERS OF IRRIGATION INSPECTORS AND CHIEF ENGINEERS.

Article 5. Irrigation inspectors are the representatives of the minister of public works and have under them the chief engineer and all those in the irrigation administrative service. Their powers and their relations to the governor are fixed by the regulations of December 31, 1885.

PUBLIC WORKS ON PRIVATE LAND.

Article 6. The owner of land crossed by a public ditch, drain, or other work destined to serve the lands of neighbors can not, without the written consent of the owners of the lands served, till the land occupied by such works in such a way as to destroy the usefulness of the works.

STOPPING OF WATER-RAISING MACHINES AND CLOSING OF CANALS.

Article 7. No indemnity can be claimed from the government for loss occasioned by a reduction or stoppage of the flow of water in a canal resulting from extreme necessity or having for its object repairs or changes recognized to be necessary, or by any measure which the irrigation inspector may deem necessary in order to maintain the volume or regulate the flow of water—such, as for example, the closing of a canal or the suspension of irrigation for a certain number of days on all or a part of a canal, so that other places in greater need of water may receive it.

In case it may be necessary to clean or repair a canal the irrigation inspector, through his agent, the chief engineer of the province, shall determine when water may best be dispensed with for irrigation that these operations may be carried on. However, having commenced any work of this kind, the irrigation inspector should act in accord with the governor, as required by the provisions of the regulations of December 31, 1885, fixing the powers and relations of inspectors of irrigation and governors of provinces.

The governor should notify and consult those interested or their legal representatives.

CONSTRUCTION OF PRIVATE DITCHES.

Article 8. If the citizens of a village desire to construct a canal on their own lands for their own use they shall apply to the governor. He will communicate the application to the inspector of irrigation, accompanying it by his recommendations and advice, and if the inspector agrees, the governor will approve or reject the application as the circumstances may warrant.

The ditch thus authorized shall be constructed at the expense of the applicants and their associates.

However, privileges so extended shall not permit the parties to debar neighboring property owners from utilizing the ditch for the irrigation of their lands, even during low water, after the original applicants shall have received what they need for their own lands. These neighbors shall in such cases become contributors toward the cost of construction and maintenance in proportion to the extent to which their lands may be benefited by the ditch.

DITCHES THROUGH LANDS OF PERSONS NOT BENEFITED.

Article 9. When a property owner finds that, without the construction of a ditch upon land not belonging to him or not served by a Nili [a] canal or by a ditch already constructed on the property of others, it is impossible for him to irrigate his own land, on account of his being unable to arrive at an amicable agreement with the proprietors of the private works or their legal representatives, he may make a statement of the case to the governor, who will communicate the same to the inspector of

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[a] A canal which flows only during the Nile flood.

irrigation, with his recommendations and advice. The latter will then examine the situation, on the ground, and will give his decision after hearing the parties interested or their legal representatives, should such appear. The chief engineer of the province or his deputy may be delegated for this work.

Fourteen days' notice shall be given as to the day and hour of the inspection. Such notice shall be given either to the owners or to their legal representatives, as the case may be.

But if the ditch or Nili canal is to furnish water either running naturally or elevated by a machine, and the property owners oppose its construction because it may injure the land it traverses, the inspector of irrigation shall go to the place himself and base his report on a careful survey.

If the report is favorable to the applicant, and the governor, after having acquainted himself with the facts, agrees with the inspector, a decision to this effect shall be rendered by the inspector. This decision shall be transmitted, as prescribed by law, to the opposing parties. The latter may, within fifteen days from such notice, appeal to the minister of public works, whose decision shall be final.

If the governor and inspector of irrigation do not agree, the case shall be submitted to the minister of public works. The applicant must always pay for the land occupied by the new ditch and the delinquent taxes on the same; also indemnity for all damage occasioned. The amount to be paid shall be fixed by the commission mentioned in article 27 of this decree.

Article 10 of the decree of March 8, 1881, is hereby repealed.

INSUFFICIENT SUPPLY OF WATER IN A DITCH.

ARTICLE 10. An irrigator who believes that he does not have sufficient water for his purposes, should notify the governor, who should in turn communicate with the inspector of irrigation, accompanying his report by his recommendation and such information as he may deem necessary, so that the inspector may determine whether or not the ditch which irrigates the cultivated land has sufficient capacity, and as to whether it should be enlarged. The inspector will base his judgment on the extent of irrigated land and the character of the irrigated crops.

If the neighboring property holders object to the enlargement of the ditch, as may be recommended by the inspector, the provisions of the preceding article are to be observed, and if the enlargement is for the passage of summer irrigation water the regulation set forth in paragraphs 2, 3, and 4 of article 9 shall apply.

EXCHANGE OF DITCHES.

ARTICLE 11. The rules and forms prescribed by article 9 will apply also where a party desires to irrigate his land during high Nile by means of a ditch other than the one which ordinarily serves him, but during low water no exchange of ditches will be permitted without the consent of the parties owning the land through which the new ditch would pass.

CONSTRUCTION OF LATERALS, OR INSTALLATION OF WATER-RAISING DEVICES ON CANALS.

ARTICLE 12. If a party desires to build a lateral gate, or a sakiyeh, or other elevating machine on a canal to irrigate the land bordering the same, he must submit his request to the governor, who will communicate it, accompanied by his recommendations and advice, to the inspector of irrigation; the latter will refer the matter to the chief engineer of the province, who, in the case of the sakiyeh, if he approves the request, will furnish the necessary authorization, but if it concerns a lateral will return the papers to the inspector for his approval.

In all cases a copy of the authorization shall be transmitted to the governor, together with a statement that the discharge of the canal is sufficient to supply the

lateral or the land to be watered by the sakiyeh without injury to those using water from the same canal below.

The chief engineer shall first require the applicant to agree to pay all expenses incident to and judged necessary for the regulation of the flow of water into the lateral and the maintenance of the banks of the canal in good condition. He shall designate the location of the lateral or sakiyeh.

Regulations for establishing fixed or portable elevating machines operated by steam, wind, or water power are set forth in the decree of March 8, 1881.

It will not be allowable in any case to install a sakiyeh or a tabout without first securing a permit. This permit will be furnished free of charge.

CLOSING A DITCH TO PREVENT INJURY TO ADJACENT LANDS.

ARTICLE 13. When, upon the claim of the owners interested or their legal representatives, the inspector of irrigation finds that a ditch is useless for irrigation, an obstacle to the drainage of bordering lands, that it absorbs water from bordering lands or loses it in transit, or, in fact, that it is a detriment to agriculture in any way, he should, after consulting the governor and after the latter has heard the interested parties, communicate his recommendations to the minister of public works, who will order the canal to be closed at the end of the harvest and will permit the adjoining property holders to fill it up if it be shown that the land irrigated by the ditch can be watered from another without injuring lands or agriculture in any way. The tract of land occupied by the ditch thus filled in shall be subject to the laws relating to such land.

INCREASING OR DIMINISHING THE SIZE OF THE HEAD GATE OF A DITCH OR CHANGING THE LEVEL OF THE BOTTOM OF THE SAME.

ARTICLE 14. If the inspector of irrigation believes that a head gate of a ditch is too large or that its flow permits the passage of a volume of water in excess of that needed by the land irrigated by the ditch, he should so inform the governor, who will invite the parties interested, or their legal representatives, to meet him on a certain day. After having the opinion of the inspector stated to them, they will fix, if they approve the recommendations of the inspector, the time when changes may be made. The time should be so chosen that crops will not need irrigation while the work is being performed.

If the parties object to the recommendations of the inspector, the case will be referred by the governor to the minister of public works, who will act as he deems expedient regarding the proposed changes.

If it is necessary to enlarge the head gate of a ditch or to lower the level of the bottom of the same so that sufficient water may be delivered, a certain time shall, in like manner, be fixed for the alterations.

In all work of this nature the government will bear the expense.

DRAINS PASSING THROUGH LANDS OF PARTIES NOT BENEFITED.

ARTICLE 15. Where, in order to drain his farm, a party has to construct a channel across the land of another, and the parties can not come to an amicable agreement, a complaint should be presented to the governor, who will transmit it, accompanied with his recommendations and advice, to the inspector of irrigation. The latter will fix the course of the drain; the governor and the inspector of irrigation shall agree as to how the land for the drainage channel shall be acquired. If they fail to agree, the case shall be submitted to the minister of public works, who, if he approves of the construction of the drain, shall take such steps as he may deem necessary to accomplish the work. All expenses thus incurred and the indemnity charged must be paid by the parties benefited. The construction of the drain shall not in any way injure land through which it passes.

REPAIRING A DITCH OR DRAIN TO PREVENT DAMAGE.

ARTICLE 16. A party whose land is injured by a ditch or drain which passes through it, whether such injury be due to a partial filling in of the ditch or drain or to insecure construction of the banks of the same, may appeal to the governor, who, after consulting with the inspector of irrigation or with the chief engineer of the province, may order the closing of the ditch or drain or may compel the owners to clean it if he deems this sufficient. If the ditch or drain is essential for serving other lands, the governor will require the owner or owners of the same to keep it in good condition or pay damages to those injured.

CHANGING THE LOCATION OF A DITCH WHICH DOES NOT MEET THE DEMANDS OF THE IRRIGATORS UNDER IT.

ARTICLE 17. When a party finds that a ditch passing through his land makes the irrigation thereof difficult, and he desires to replace the channel by another, he may present a petition to the governor, who will transmit it, accompanied by his recommendations and advice, to the inspector of irrigation, who, after having consulted with the governor, will authorize the closing of the ditch and the substitution of another at the expense of the owner of the land, provided that the new ditch is in all respects as good as the first and fulfills the required conditions, and that the original channel be not closed until the new one is in condition to be used.

But if the ditch concerns only the owner of the land through which it passes, he may replace the same by another channel upon his own land without having to obtain a permit.

DIFFICULTIES WHICH MAY ARISE IN CONNECTION WITH THE REPAIR OF DITCHES.

ARTICLE 18. If any party disagrees with his associates as to whether or not a canal should be repaired, and so notifies the governor, the latter shall delegate the chief engineer to make investigation on the ground and ascertain the facts. If it is considered necessary to have the repairs made, the governor will notify the interested parties to do so.

But if the parties are found to be unable to perform the necessary work, either for want of labor or money, the government may defray the expenses necessary for making the repairs and reimburse itself for the money so expended by numerous payments from those benefited, the amounts of such payments to be fixed by the province according to the means of the parties. The government may renounce all claims for reimbursement if the parties are recognized as being poor.

The minister of the interior will decide as to whether poverty exists or not

DESTRUCTION OF DIKES OR FILLING IN OF DITCHES OR DRAINS.

ARTICLE 19. If any party complains to the governor that one of his associates in an irrigation ditch or drain maintained at the expense of those interested, under the provisions of article 2, has destroyed the banks or has filled in or encroached upon a part thereof, the governor will communicate the grievance, accompanied with his recommendations and advice, to the inspector of irrigation, who will make a personal examination of the ground or delegate the chief engineer of the province to do so, after having given notice to those interested at least fourteen days in advance. If it is found that dikes have been destroyed or channels filled in, the inspector will make an estimate of the cost of reestablishing the works as they formerly stood, and the governor will require, according to law, the offender to restore the property he has damaged. In case he refuses he will be obliged to bear the expense of such repairs.

In case an owner or a tenant complains to the governor that some one has intercepted the water of a ditch which serves him for irrigation, the governor, as stated in the foregoing paragraph, will transmit the complaint, accompanied with his recom-

mendations and advice, to the inspector of irrigation, who will visit the place himself or delegate the chief engineer of the province to do so, after having given notice to the interested parties at least fourteen days in advance; if it is found that the complainant actually irrigated his land from the same ditch during the preceding year, the inspector of irrigation will so inform the governor, who will take such lawful measures as may be necessary in order that the water may flow as formerly, and that nothing may prevent his use or enjoyment of the ditch. The governor will proceed immediately in the execution of these measures, all expenses being borne by the party or parties who intercepted the water. These expenses may be, in all of the above cases, recovered in the manner prescribed in the decree of March 25, 1880.

REMOVAL OF TREES PLANTED ON LEVEES AND CANAL BANKS.

ARTICLE 20. If it is found that trees planted on levees, or banks, or footpaths of canals are private property, and are obstacles to the flow of the water, to navigation, or to travel on the banks, the inspector of irrigation or the chief engineer of the province shall order the owner to remove them. If he does not do this within eight days, the inspector, after having obtained the written consent of the governor, shall break or cut down the trees, sell the wood, and remit to the owner the receipts from the sale after deducting expenses.

CULTIVATION OF THE BANKS OR BED OF A CANAL.

ARTICLE 21. The customary practice of cultivating the sides of canals not reached by the water and the beds of Nili canals will be permitted, but the cultivator of such land can not claim any damage for injury occasioned by necessary repair or cleaning of canals. However, the inspectors will enjoin the agents in charge of the work to take all possible precautions to prevent loss to the growing crops.

A farmer of such government land will not be required to pay rent therefor when the crop shall have been damaged as a result of necessary public work executed before harvest time. He will, however, be obliged to bear the loss of the damaged crops.

MAKING A ROAD ALONG A CULTIVATED BANK.

ARTICLE 22. If it is necessary to use for a public highway the bank of a canal ordinarily cultivated, or if for any reason it is desired to stop cultivation thereon, the inspector of irrigation will request the governor to inform the farmer that cultivation will not be permitted after the crops then growing shall have been harvested. If, in spite of this notification, the farmer persists in using the bank for raising crops he will have no claim against the government should the crops be destroyed by order of the governor. But if the land along the bank yields revenue through taxation, the government must remit the taxes thereon and declare it a public highway.

CONSTRUCTION OR REPAIR OF PRIVATE HEAD GATES ALONG THE BANKS OF THE NILE OR OF A CANAL.

ARTICLE 23. If the inspector of irrigation finds a head gate on the bank of the Nile or of a canal, or any other works of protection, badly constructed or in poor condition, or in any way a source of danger to the banks, he will inform the governor, who will give orders to the owners of the works to make changes or repairs within a period of forty days during the winter season. If the owner fails to do this the inspector will request the governor to set aside another forty days for the accomplishment of the work.

If, after the second notice on the part of the governor, the owner of the head gate refuses to make the changes or repairs, the governor may have the work done and e expense will be recovered as provided in the decree of March 25, 1880.

If the construction of the head gate is not finished at the time of high Nile, the inspector of irrigation may order its immediate closing and ultimate removal where the security of the banks demand it. He should be careful to inform the governor of his action, and to conduct the water in some other way than through this head gate to the lands usually irrigated.

WORKS FOR PROTECTION AGAINST INUNDATION.

ARTICLE 24. When, to protect the country from inundation, it is necessary to occupy a tract of land belonging to individuals, whether it be cultivated or not, or to destroy a building of any kind situated on the said land, the area of the property so occupied will be measured, and the valuation will be fixed by the commission provided for in article 27. After having heard the owner and the inspector of irrigation the commission will inform the governor of the estimated advantages resulting from these works.

The sum fixed by the commission will be paid by the minister of public works. No appeal can be taken from the decision of the commission.

In case of danger during high Nile the governor may act immediately. He may occupy land, whether cultivated or not, destroy a house or any other structure in the building of works necessary for protection; in this case the estimate of damages will be made by the governor or his deputy, acting with the chief engineer or the engineer of the district and four prominent persons, two of whom shall be chosen by the owners of the property and two by the governor. In case of a tie the governor or his deputy shall cast the deciding vote.

The damages shall be paid by the minister of public works.

CHANGE IN THE COURSE OF THE NILE.

ARTICLE 25. If the Nile should form, owing to a change in its channel, an island or a deposit of alluvial soil near a bank upon which is erected an elevating machine duly authorized by the government, and the government should deem it expedient to sell or rent this island or the tract of land, the owner of the machine shall have a right to dig a ditch through the alluvial land to bring water to his machine without indemnification to the tenant or owner.

LOADING AND UNLOADING BOATS.

ARTICLE 26. Boats will be allowed to load and unload their cargoes at all times at the landings established for that purpose upon the banks of the Nile or of canals, provided that no damage be done to these banks and that travel along the same be not impeded.

When the landing places are separated from the water by land belonging to private individuals and can not be reached by any other route, the owners of the boats and of the land must agree upon the location of a road for the transportation of the cargoes of the boats, as well as upon a reasonable price for the right of way. If the owner of the land objects to the road, he will be obliged to accept the price for the right of way fixed by the commission provided for in article 27.

Generally, the owners of boats will be permitted to construct or repair them only on the footpaths near the water edge.

BOARD OF APPRAISERS.

ARTICLE 27. A commission is hereby instituted to act where parties fail to agree on the amount of indemnity due, whether it be for lands necessary for the construction of ditches or drains or for any other case of indemnity provided for in this decree.

This commission shall be composed of the governor or his deputy, as president, the chief engineer, and two prominent citizens of the province chosen by each of the interested parties.

In case of a tie the president shall cast the deciding vote.

If the chief engineer is absent or hindered from attending, the inspector of irrigation shall appoint the principal deputy engineer to take his place.

OWNERS OF BOATS CAN NOT COLLECT DAMAGES FROM THE GOVERNMENT.

ARTICLE 28. The owners of boats or of cargoes can not claim any indemnity against the government for delay occasioned by the closing of a canal or by insufficient water in the canal or in the Nile. They shall be advised of the closing as soon as possible.

WRECKING OR GROUNDING OF BOATS.

ARTICLE 29. If a boat is wrecked or runs ashore along the Nile or in one of the public canals or in a basin in such a way as to form an obstacle to navigation or to the free passage of the water, the governor will notify the owner of the boat, who is held responsible for notifying the owner of the cargo to remove the boat, and if the latter does not do so within eight days after receipt of the notice the governor will have the work done at the expense of the owner, and the latter will have no claim against the government for indemnity for any damage which may be done to the boat or cargo in the course of such removal.

If the owner does not pay the expense of removing the boat within eight days after notification to do so, the governor shall have the right to sell the boat and its cargo. The returns from such sale shall be remitted to the owner after deducting the said expenses. If the expense of removal is in excess of the value of the boat and cargo combined and the owner is unable to pay the difference on account of poverty, such excess shall be borne by the government.

Should a boat founder in a narrow canal or in a lock or in front of the opening of a lock or head gate, etc., so as to stop navigation or render it difficult or diminish the discharge of water in the canal or through a lock or head gate, the inspector shall take immediate measures for removing the said boat from the passage so rendered dangerous, and at the same time inform the governor regarding the whole matter.

The expense of removing the boat will be borne by the government, but the owner will have no claim against the government for any damage which may be done to the boat, its accessories, or cargo in this work.

As to the procedure after the boat has been removed from a channel where it threatened danger to navigation or other interests, the provisions of the first part of this article shall apply.

ESTABLISHMENT OF FERRIES ON A CANAL.

ARTICLE 30. In order to establish a ferry on a canal it is necessary that the proposed plan and site be approved by the inspector of irrigation, in addition to the permit from the minister of finance.

In regard to ferries already in operation, if the inspector of irrigation believes that they are so located as to be injurious to irrigation or navigation and that they can be moved to a neighboring site without interfering with traffic, he may notify the governor to have the change made.

If such change be not possible, the inspector of irrigation and the governor will, after conferring, apply to the ministers of finance and public works, who will decide whether the ferries should be suppressed or not. If they decide that such action should be taken the ferries shall be relieved from taxes and replaced by bridges which shall be public highways. The owners of the ferries will have no claim for indemnity against the government.

ARTICLE 31. It is prohibited, under the penalties prescribed by the native penal code, for anyone to require or collect any payment whatsoever for the privileges which authorized boats have of loading and unloading their cargoes on the banks of the Nile, of a canal, or of a public drain.

OFFENSES.

ARTICLE 32. Offenses will be punished by imprisonment from fifteen days to two months and a fine at least equal in amount to the damages caused, to be judged by the minister of public works, but the fine can not in any case exceed twice this amount.

First. Those who, without special authorization—

A. May have obstructed a water course by a dike, rocks, or any other obstacle.

B. May have opened or closed the gates of locks or interfered with any of the machinery which serves to protect the bridges or head gates.

C. May have broken a dike that was constructed across a canal, with the object of closing or reducing the discharge.

D. May have established on the banks of the Nile, of a canal, or of a public drain any structure whatever, hydraulic wheel, sakiyeh, pump, etc. (all structures or machines established under these conditions will be immediately removed).

Shadufs, natalis, and Archimedean screws may be established without securing permits, provided that the banks are not cut or in any way damaged.

E. May have cut the banks of the Nile or of an irrigation canal or drain, or constructed a gate for the passage of water.

F. May have removed the earth forming the banks.

G. May have changed in any way a lock or a gate constructed of masonry, whether the lock or gate be public or private property, constructed upon a bank of the Nile or of a public canal.

H. May have removed earth, stone, wood, or any other material from the banks of the Nile or of a canal or from any work of protection, or who may have committed acts which might injure works of art.

The sheiks of the villages who may have taken charge of these works of art will be held legally responsible by the government for the said acts, unless they have informed the government that they will no longer act in this capacity, so that guardians might be appointed by the government.

Second. Those who may have interred a body in the banks.

Third. Those who may have taken water from a canal, whether by opening the gate of a canal or ditch or by making an opening in the bank or by raising the level of the water during the time the inspector of irrigation or other duly appointed authority shall have given notice that water should not be used.

ARTICLE 33. The following offenders will be punished by a fine of from 25 to 200 P. T. ($1.23 to $9.86) and imprisonment from five to thirty days:

First. Those who, without written authority from the inspector of irrigation, may have diverted water from a drainage canal to a public canal.

Second. Those who, without special authorization, may have constructed over a canal any bridge, either permanent or temporary, or who may have established a pipe or a siphon.

ARTICLE 34. The following offenders will be punished by a fine of from 10 to 50 P. T. ($0.49 to $2.47) and imprisonment from one to fifteen days:

First. Those who may have deposited upon the banks or berms of a canal the material obtained from excavating or cleaning a ditch, a conduit to a sakiyeh, or a steam pump.

Second. Those who may have damaged the banks of canals or public drains by running water over them from the fields or by discharging into the channel of a public drain sand or mud carried by water.

Third. Those who may have driven stakes in a canal to hold fishing nets.

ARTICLE 35. Those who may have thrown into the Nile, a canal, or a public drain dead animals or any other substance which would taint the water will be subject to a fine of 200 P. T. ($9.86).

Those in charge of the guards must always remove dead bodies from the water and bury them.

ARTICLE 36. The penalties, fines, and imprisonments provided for in articles 32, 33, and 34 may be applied separately.

ARTICLE 37. In addition to the prosecution for offenses as above provided for, offenders will always be required to restore premises to their former condition; if they refuse, the necessary work will be performed at their expense by the government, and the sum expended will be recovered in the manner prescribed in the decree of March 25, 1880.

ARTICLE 38. Offenders will be tried before a commission composed of the governor, the chief engineer or his deputy, and three prominent citizens of the province, to be chosen by the minister of the interior.

A majority vote shall decide.

No appeal may be taken if the sentence carries a fine only.

Where the offender is condemned to imprisonment, he may appeal to a special committee sitting at the ministry of the interior and composed of the under secretary of state as president, a khedival councilor, and a delegate from the ministry of public works.

The appeal must be lodged by a declaration to the province or to the government within three days after the decision has been handed down.

The appeal will not be received unless the party condemned has at that time paid the fine and damages imposed, subject to refund in case of acquittal.

ARTICLE 39. Special regulations of the minister of the interior shall fix the procedure to be followed, whether before the commission or before the special committee.

ARTICLE 40. The sheiks and watchmen of the towns and villages, the overseers of the chifliks and ezbehs,[a] of the government lands, and of the Daira Sanieh will be held responsible for the safe-keeping of the dikes and canals and all works of art which may be located within their respective jurisdictions and which have been consigned to their care. In case of offense they will be held personally liable for the expense of repairing the works should the offenders be not apprehended.

ARTICLE 41. The fines and other expenses shall be collected under the provisions of the decree of March 25, 1880. In case the fine is not paid, the condemned shall, in lieu thereof, be imprisoned one day for each 30 P. T. ($1.48) of the fine. Such imprisonment will be ordered by the governor.

ARTICLE 42. All previous acts in conflict with this decree are hereby repealed.

ORDER OF THE MINISTER OF THE INTERIOR OF JULY 16, 1898.

ARTICLE 1. All infractions of the law of February 22, 1894, relative to levees and canals, shall be proven by testimony drawn up and signed by the engineer of the district or by a referee appointed by the chief engineer, and signed in addition by the omdeh[b] or by one of the sheiks of the village in the province where the offense was committed.

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[a] Chifliks are concessions of large areas of land related to the Abadieh lands and ruled by the same decree of 1842. They were given to the vice-royal family exclusively. Under Abba Pasha, however, the government ceded some of this land to several high functionaries of the state.

Ezbehs are hamlets or settlements isolated from neighboring villages, the inhabitants not being included in the census of the villages.

[b] An omdeh is the chief of a village; he is superior in authority to a sheik.

If the omdeh and the sheiks are absent, the said testimony shall be signed by the head officer of the district, or by one of the referees of the province or of the districts, or by an agent of police, on condition that they have presented direct evidence of the offense.

In the absence of these officials or of an agent of police, it will be sufficient in the prosecution if the testimony be countersigned, or simply signed, without a second signature being necessary, by an inspector of irrigation, a chief engineer, a director of public works, a superintendent of contracts, or an engineer appointed by the inspector of irrigation.

If the chief engineer should appoint a referee, or the inspector of irrigation an engineer, to take testimony in accordance with the provisions of this article, the governor should be informed immediately of the name of the person so appointed and the object of his appointment. The authority and duties of a person so appointed shall concern only a single case or a group of cases or a certain locality, in which the appointee must spend a fixed period, such as, for example, the breaking of regulations concerning rotation in the use of water from a certain canal or in a certain district during the period of rotation.

ARTICLE 2. The testimony shall be dated and must contain the following information:

(1) The full name, occupation, and residence of the accused.

(2) Proof of the act constituting the offense and of the time and of the place where committed.

All testimony shall be recorded, together with all the circumstances arising from the culpability of the accused, and shall be forwarded within twenty-four hours to the governor, accompanied by a statement fixing the amount of damages.

ARTICLE 3. A special register shall be kept at the office of the governor by an employee, who shall act as recorder for the commission. In this register he shall enter immediately—

(1) The date of the receipt of the report.

(2) The date of the taking of testimony.

(3) The full name, occupation, and residence of the accused.

(4) The character of the offense.

ARTICLE 4. Within twenty-four hours after receipt of the report the recorder shall summon the accused to appear before the commission. This summons, in duplicate, must contain—

(1) The full name, occupation, and residence of the accused.

(2) The character of the offense.

(3) Citation of the relevant provisions of the law.

(4) The day and hour when the accused shall appear.

At least three full days must intervene between the date of the summons and the date of appearance.

ARTICLE 5. An agent of the government shall be appointed to deliver a duplicate of the summons to the accused.

He shall make mention of such delivery at the bottom of both the original and duplicate summons, and shall affix the date of his signature.

The accused shall also sign or stamp the summons. In case of refusal or absence such fact shall be noted thereon, and the original summons shall be delivered to the sheik, who shall acknowledge receipt thereof.

ARTICLE 6. The recorder shall enter in the register provided for in article 3 the date of the summons and all proceedings to and including the final decision.

ARTICLE 7. The accused shall appear before the commission in person on the day and hour specified.

He may not in any event claim any irregularity whatever in the summons, for the fact of his appearance would nullify any such claim.

ARTICLE 8. Testimony duly signed shall be accepted as fact until proven to the contrary. The recorder shall read the testimony, together with any report which may accompany it.

Following this the accused will set forth the character of his defense, and, if the same court tries the case, he will then give his testimony.

The character of the defense and the depositions of testimony shall be briefly stated by the recorder in a report. The commission shall, before adjournment, give its decision, which must be justified by the facts.

They may require additional testimony if they believe it necessary. In such event they shall fix the day and hour when the new evidence shall be heard, which must be within fifteen days.

ARTICLE 9. If the accused does not appear at the first hearing, the commission shall ascertain if the provisions of articles 4 and 5 relating to the summons have been observed. If any irregularity be found, they shall order a new hearing, which shall take place within three days.

ARTICLE 10. If the summons has been properly issued, judgment by default will be given, and no appeal may be taken.

ARTICLE 11. Where an appeal is granted in accordance with the provisions of article 38 of the law on levees and canals, the accused, in making the appeal, must produce a receipt showing that he has deposited in the treasury of the province the amount of the fine and damages which have been imposed.

The appeal will not be received if it is not accompanied by the said receipt.

The appeal shall be transmitted within three days to the minister of the interior, with the decision and the other papers in the case.

ARTICLE 12. During the period of rotation in the summer—that is, the period during which rotations apply to machines and pumps—the commission shall assemble at least once a week. But if, within three days before the time of meeting, there has been no summons, and there is no case of emergency, the governor may give notice to the members of the commission that no meeting will be held during the said week.

ARTICLE 13. The governor shall be charged with the execution of the decisions, both of the commission and of the special committee of appeal.

APPENDIX II.

INSTALLATION OF MACHINES FOR ELEVATING WATER.

[Decree of March 8, 1881.]

ARTICLE 1. Any person, before establishing a machine for elevating water either for irrigation or drainage, whether the machine be stationary or movable, or propelled by steam or by a current of water, or by the wind, must receive permission from the public works ministry. This permit carries with it no right or title to the public or private lands traversed by the pipes, conduits, aqueducts, head gates, or occupied by the pumping plant, in any way whatsoever. The government remains neutral in all respects in all disputes between the people and the person receiving the permit and leaves to him all responsibility resulting from damages which may occur in the installation of the plant or in any other way.

ARTICLE 2. The erection of stationary elevating machines will be authorized only upon the banks of the Nile. At the same time the minister of public works may make exception and authorize the establishment of such machines upon certain canals. The minister is to be sole judge of the expediency of issuing a permit, and to him will be left all freedom regarding all agreements and conditions to which it will be subjected, as the case may demand.

ARTICLE 3. All machines for elevating water, whether stationary or movable, must be so installed as not to interfere with travel along the banks or the navigation of the canals, to respect all existing rights, and not add to the expense of maintenance of the canals or their banks, or to the defense of the country against inundation.

ARTICLE 4. In case the applicant fails to comply with the conditions and obligations imposed by the permit, it will be canceled without any claim on the government on account of such procedure as it may deem necessary to reimburse itself for such damage as may be done.

ARTICLE 5. A site for the installation of a machine at a certain place may not be changed except by the issuance of a new permit, which will be granted without requiring the payment of additional fees.

ARTICLE 6. The Government retains the right, whenever a public utility may require, such as the execution of public works dangerous to the dikes, irrigation works, etc., to cause any authorized pumping plant to be removed.

ARTICLE 7. The permit given for the installation of an elevating machine, whether stationary or movable, carries with it only the right for the applicants to install the plant in order to take water from a canal or the Nile. It carries with it no assurance from the government of a supply of water for the machine, nor does it insure a passage for the water elevated by the machine. The applicants must come to an understanding with their associates, or the people whose land they must cross, without interfering with the government in any way. In order to conduct water over waste or other land of the government, the applicant must secure a special permit. It is prohibited to make ditches to bring the water along the banks of the canals or of the Nile, as well as upon the roads or slopes of the banks.

ARTICLE 8. The ditches or conduits for carrying the water from the machines to the land will be constructed in such a manner and be of such a kind as not to interfere with travel, the flow of water, or with irrigation, according to the rights reserved by the people to whom the applicant alone remains responsible. The government will allow such construction as it deems safe and necessary for permitting the passage of conduits under dikes and roads and under or above canals.

ARTICLE 9. For the general good, in case of exceptional low water, or when the flow of the canal becomes greatly inferior to the needs of the agriculture which it serves, the public works ministry, in accordance with a measure generally applicable to canals or a single reach of a canal, may order the immediate closing of the elevating machine, or reduce the capacity of the same in accordance with its location, the relative importance of the machine, the area of the land which it irrigates, and in no case will the government incur any responsibility for damage caused to agriculture.

ARTICLE 10. Under the provisions of article 7, the ministry of public works is, under certain conditions, authorized to permit the use of a public Nili canal for carrying water from the elevating machine to the land to be irrigated, under the following reservations:

(1) Such permission will be given only during the season of low water and ends when the water of the Nile will flow freely in the canal.

(2) Permission will be given only when the proprietors of the land who use the Nili canal have given their general consent.

(3) If it is found necessary to construct dams to maintain the level of the water along a Nili canal, these must be of earth and they must be built by the owner of the machine, in case of necessity, by the government, but at the expense, risk, and peril of the proprietor, before the water of the Nile can flow freely into the canal.

(4) Finally, the owner of the machine is alone responsible to the people for all damage occasioned by the breaking of dams, percolation, and delay in building the dams at the time the supply of water is available.

ARTICLE 11. Any person who, contrary to the foregoing provisions of this decree, may have installed a stationary or a movable machine without receiving a permit, must, before August 31, 1881, apply for a permit under the conditions prescribed by

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Bul. 119. Report of Irrigation Investigations for 1901 under the direction of Elwood Mead, chief. Pp. 401. Price, 50 cents.

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